N-1

RADIAMIC C-1 ENGINE

Thiokol CHEMICAL CORPORATION

C-1 ENGINE FINAL REPORT

Prepared for George C. Marshall Space Flight Center
Under Contract NAS8-15486

PROPELLANT VALVE QUALIFICATION

Volume II

Book 2

Report RMD 6203-02

17 July 1967

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● REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

RQ7-49185B

PROPELLANT VALVE QUALIFICATION

VOLUME II
BOOK 2

APPENDICES
I thru O

Thiokol
REACTION MOTORS DIVISION

APPENDIX I

SHOCK TEST

ATL REPORT

Test Report No. M594-8312 No of Pages 12

Report of Test on

C-1 ROCKET ENGINE

P/N 317000-1100, S/N 761

SHOCK TEST

for

THIOKOL CHEMICAL CORPORATION

REACTION MOTORS DIVISION

Associated Testing Laboratories, Inc.

Wayne, New Jersey

Date June 12, 1967

	Prepared	Checked	Approved
By	J. McGall	P. Lobosco	T. Dowd
Signed	J. McGall	Lobosco	T. Dowd
Date	6-12-67	6/14/67	6-14-67

Administrative Data

1.0 Purpose of Test:

To subject the submitted C-1 Rocket Engine to a shock test.

2.0 Manufacturer: Thiokol Chemical Corporation
Reaction Motors Division
Denville, New Jersey 07834

3.0 Manufacturer's Type or Model No.: P/N 317000-1100 RES Engine
S/N 761

4.0 Drawing, Specification or Exhibit: Thiokol Chemical Corporation, Reaction Motors Division Specification 15169, Appendix C

5.0 Quantity of Items Tested: One

6.0 Security Classification of Items: Unclassified

7.0 Date Test Completed: May 27, 1967

8.0 Test Conducted By: **Associated Testing Laboratories, Inc.**

9.0 Disposition of Specimens: Returned to Thiokol Chemical Corporation, Reaction Motors Division

10.0 Abstract:

The submitted C-1 Rocket Engine completed the shock test with no visible evidence of physical damage. All functional and leakage data was recorded and retained by a representative of Thiokol Chemical Corporation.

LIST OF APPARATUS

Item	Manufacturer	Model No.	Calibration Date	Calibration Due Date
Variable Pulse Shock Machine	Associated Testing Laboratories, Inc. Manufacturing Div.	SH-300-VP	Calibrated prior to use	
Storage Oscilloscope	Tektronix, Inc.	564	5-16-67	8-16-67
Variable Frequency Bandpass Filter	Krohn-Hite	330A	4-5-67	10-5-67
Accelerometer	Endevco Corporation	2215E	3-23-67	6-23-67
Oscilloscope Camera	Hewlett-Packard	196A	Calibration not required	

Associated Testing Laboratories, Inc.
Wayne, New Jersey Burlington, Massachusetts

TEST PROCEDURE

The shock test was conducted in accordance with Thiokol Chemical Corporation, Reaction Motors Division Specification 15169, Appendix C.

A test fixture was secured to the platform of a shock machine and the Rocket Engine was mounted to the test fixture. The Rocket Engine was then subjected to a total of 18 shock impacts, with three shock impacts being applied in each direction of each of the three mutually perpendicular axes identified in Figure 1. Each shock pulse approximated a one-half sine wave with a peak intensity of 20 g and a time duration of 10 milliseconds.

Prior to performing the shock test, the shock machine was calibrated with a dummy load equal in weight to the test fixture-engine combination. The calibration was performed by means of a crystal accelerometer connected through a bandpass filter to a storage oscilloscope. A photograph of the calibrated shock pulse was taken and may be seen in Figure 2. In addition, a photograph was taken of the first shock pulse in each direction. These photographs may be seen in Figures 3 through 8.

At the completion of each direction of shock, the Rocket Engine was visually examined for evidence of physical damage. At the completion of each axis, the Rocket Engine was subjected to functional and leakage testing.

TEST RESULTS

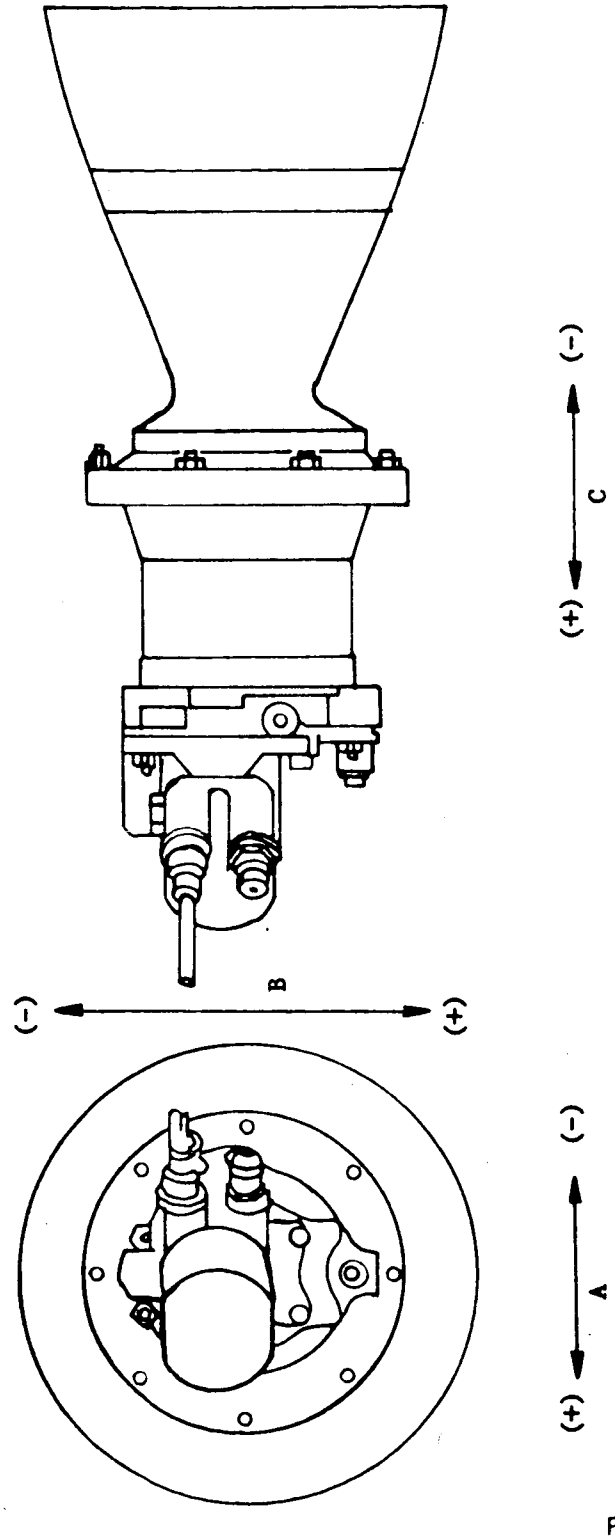
There was no evidence of any physical damage to the Rocket Engine as a result of the shock test. All functional and leakage testing was performed by representatives of Thiokol Chemical Corporation. The data for this testing was recorded and retained by the representatives and does not form a part of this report.

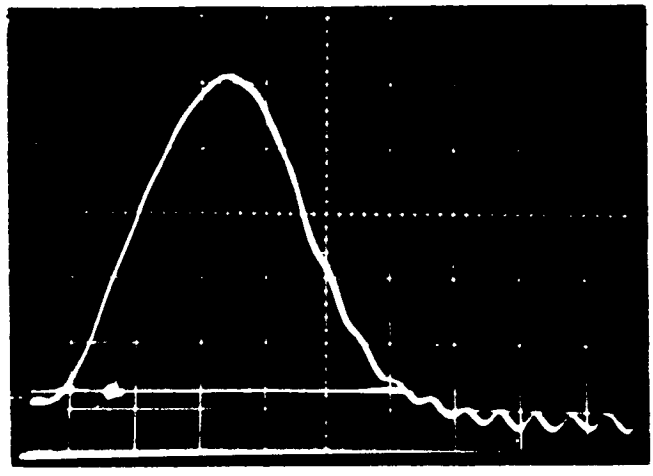
A P P E N D I X

Figures 1 through 8

Figure 1

Identification of Directions of Shock





System Calibration:

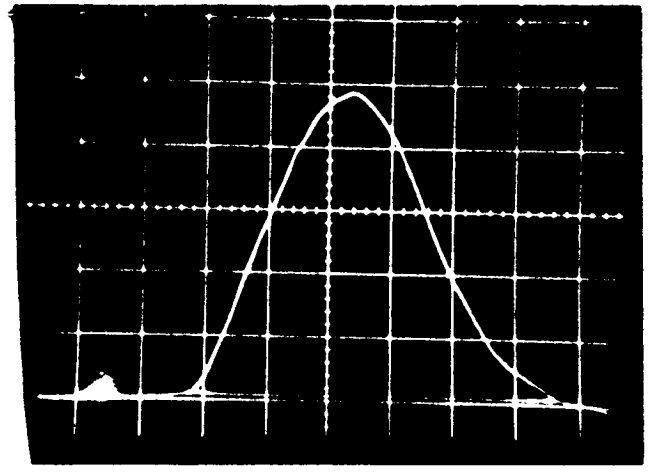
4 g/vertical division
2 ms/horizontal division

Peak intensity: 20 g

Time duration: 10 ms

Figure 2

Calibration Shock Pulse



System Calibration:

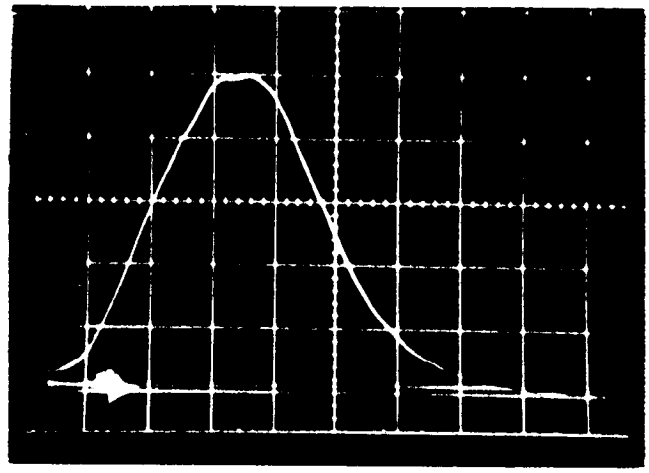
4 g/vertical division
2 ms/horizontal division

Peak intensity: 20 g

Time duration: 10 ms

Figure 3

Shock Pulse for Direction A(+)



System Calibration:

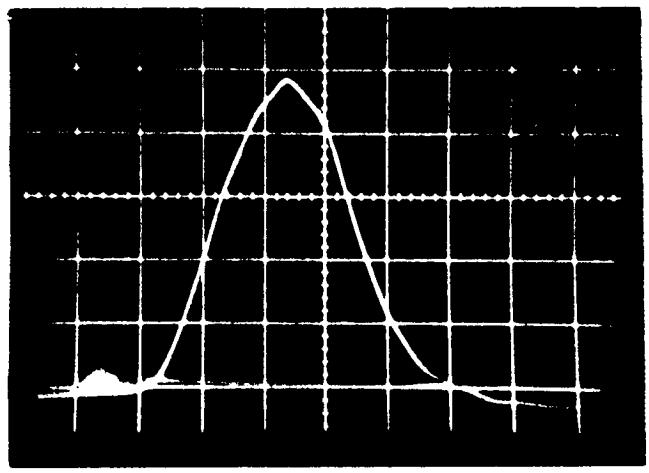
4 g/vertical division
2 ms/horizontal division

Peak intensity: 20 g

Time duration: 11 ms

Figure 4

Shock Pulse for Direction A(-)



System Calibration:

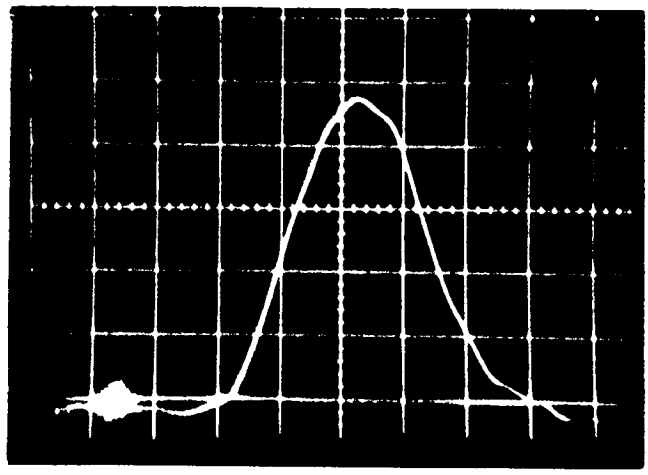
4 g/vertical division
2 ms/horizontal division

Peak intensity: 19 g

Time duration: 10 ms

Figure 5

Shock Pulse for Direction B(+)



System Calibration:

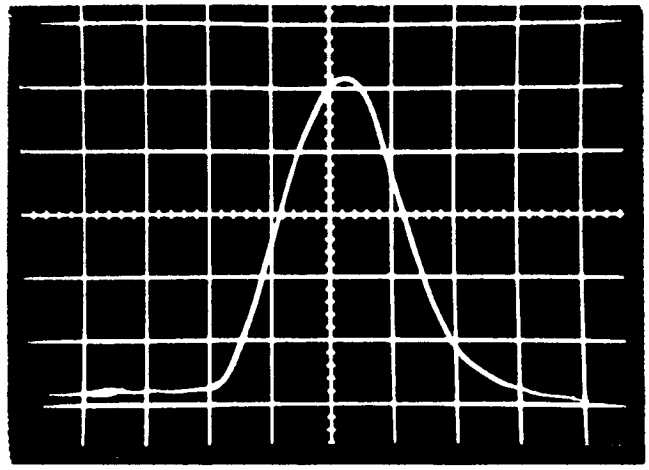
4 g/vertical division
2 ms/horizontal division

Peak intensity: 19 g

Time duration: 10 ms

Figure 6

Shock Pulse for Direction B(-)



System Calibration:

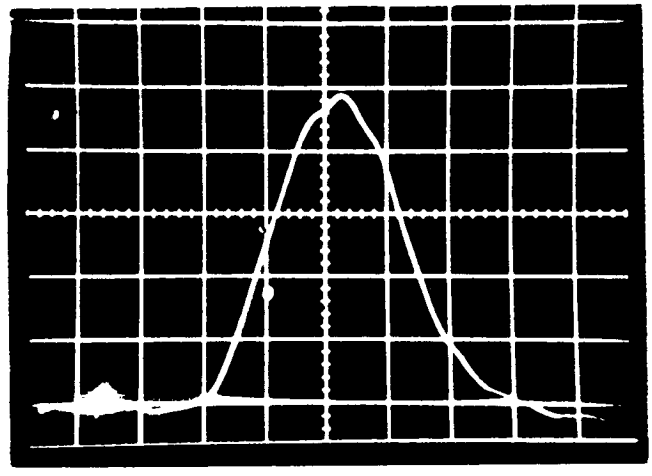
4 g/vertical division
2 ms/horizontal division

Peak intensity: 20 g

Time duration: 10 ms

Figure 7

Shock Pulse for Direction C(+)



System Calibration:

4 g/vertical division
2 ms/horizontal division

Peak intensity: 20 g

Time duration: 9.5 ms

Figure 8

Shock Pulse for Direction C(-)

Thiokol
REACTION MOTORS DIVISION

APPENDIX J

ACCEPTANCE TEST DATA FOR BIPROPELLANT CONTROL VALVE ASSEMBLY

MOOG MR 1152

ACCEPTANCE TEST DATA

FOR

BIPROPELLANT CONTROL VALVE ASSEMBLY

Valve Model Number 52-147 B
Valve Part Number 010- 49029
Valve Serial Number 235

RMD Acceptance
Date 12-29-66

Moog QA Acceptance
Date 12-29-66

Government Inspector
Date 12/29/66

NOTE

The last MR revision affecting each page of this data booklet (page 17 through 20) is indicated in the upper right-hand corner of each of the following pages.

Model 52-447 B, Serial No. 235
Test Data Check Off Sheet
Sheet 1 of 2

Moog Inc.
East Aurora, New York

TEST	PARA	LIMIT	VALUE
1. Examination of Product	3.2	a.) Conformance to external dimensions, markings, identification and finish.	Mark OK ok
		b.) Weight	Grams 788.5
2. Vibration test at 27.7 g rms	3.3	Min. Limit - 2 minutes	Vibration time 2.0 min
3. Valve Proof Pressure	3.4	No permanent set, distortion, or external leakage	Mark OK ok
4. Seat Assembly Proof Pressure	3.5	No permanent set, distortion, or external leakage	Mark OK ok
5. Dielectric Strength	3.6	.50 ma max	Pins to body 0.006 Between coils 0.008
6. Insulation Resistance	3.7	100 Megohms minimum	Pins to body 2,000 Between coils 100,000
7. Coil Resistance	3.8	Pin A to B (15±1.5 ohms) Pin C to Pin D (30±3.0 ohms)	Recorded Resistance 14.98 Coil Temperature 70 ° Resistance 14.85 Recorded Resistance 28.90 Coil Temperature 70 ° Resistance 28.64
8. Polarity Flow and Pressure Drop	3.9	Positive Signal Valve opens Fuel Side Pressure Drop Oxidizer Side Pressure Drop See attached plot	Mark OK ok psid(22 - 28) 25.0 psid(29 - 35) 31.0
9. Functional Test	3.10		

Coil Energized	Supply Pressure psig	Opening Voltage vdc	Limit vdc	Drop Out Voltage vdc	Limit vdc	Drop Out Current ma	Limit ma
Primary	465	8.9	≤16				
Secondary	345	9.8	≤16				
Primary	151			2.2	≥1.0	144	≥50.0
Secondary	151			3.7	≥1.0	123	≥30.0

Note any malfunctions during application of operating voltage at each Coil - Pressure - Voltage combination. Noise Allowed 0

Number of accumulated cycles (2000 minimum) 2005

Model 52-167 B, Serial No. 235
Test Data Check Off Sheet
Sheet 2 of 2

Moog Inc.
East Aurora, New York

	TEST	PARA	LIMIT	VALUE
10	Response	3.11		

Coil Energized	Supply Pressure	Operating Current Amperes	Opening Time Sec	Limits	Closing Time Sec	Limits
Primary	295		0.0057	< .009	0.0026	< .005
Secondary	360		0.0170	< .050	0.0022	< .005

Photographs attached

11	Flushing & Drying	3.12	(Completed)	Mark ok ok
12	External & Gross port Leakage	3.13	Pressure applied to fuel side only, oxide side inlet and outlet open (<10^{-4} cc/sec)	1.29×10^{-5}
			Pressure applied to oxide side only, fuel side inlet and outlet open (≤ 10^{-4} cc/sec)	1.94×10^{-5}
13	Internal Leakage	3.14		

	Oxide Side		Fuel Side	
	First Check	Second Check	First Check	Second Check
50 psig	0.8	0.7	0.0	0.2
465 psig	0.0	0.2	0.0	0.0

< 1 cc/12 min at 50 psig

< 1.0 cc/12 min at 465 psig

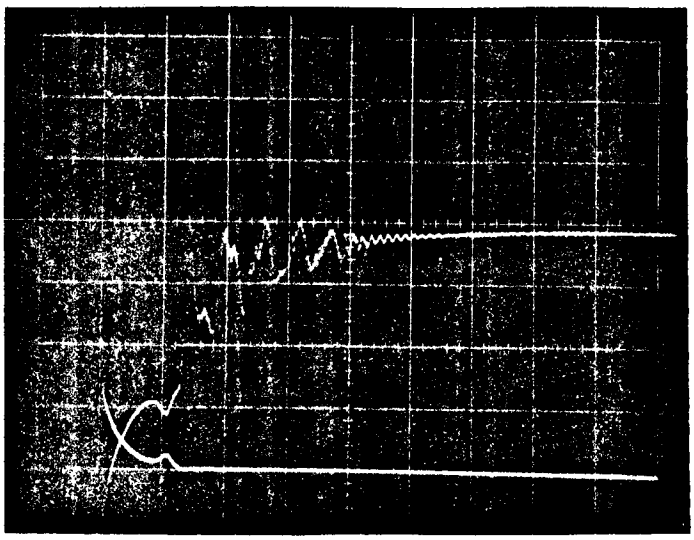
Accumulated open close cycles Total 6355
Accumulated energized time Total 1 min 47 sec

14	Reverse seat Leakage	3.15	≤ 3 cc/6 min	Fuel 0.2 cc oxidizer 1.80 cc

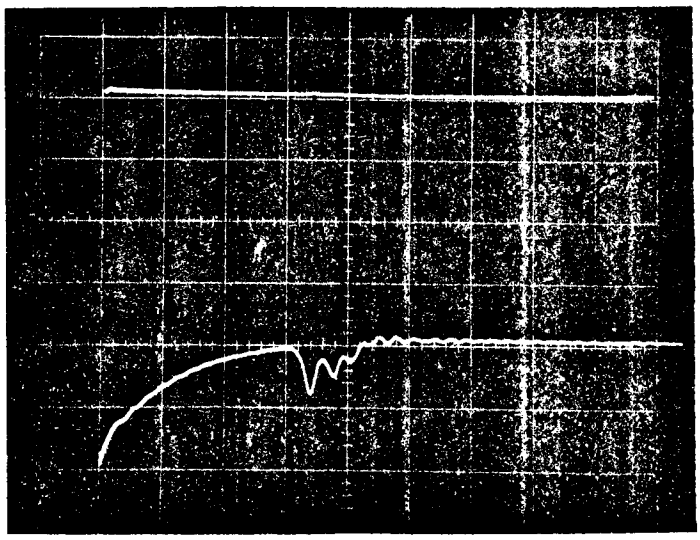
REPONSE TIME

MODEL 52-147 B

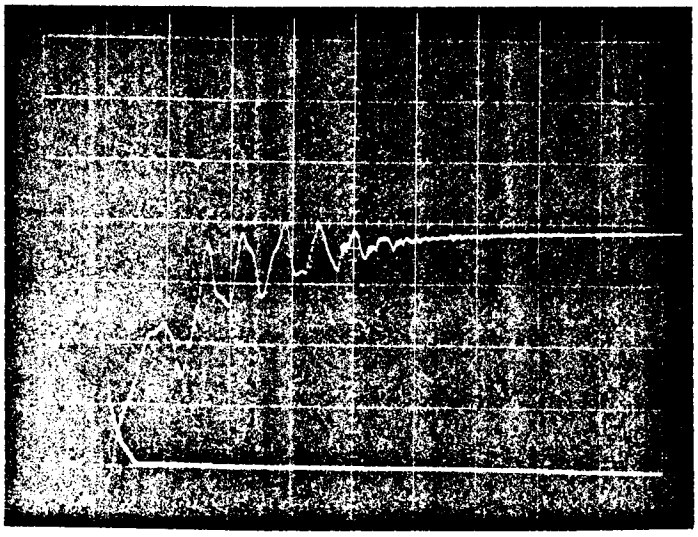
S/N 235



Secondary Off



Secondary On



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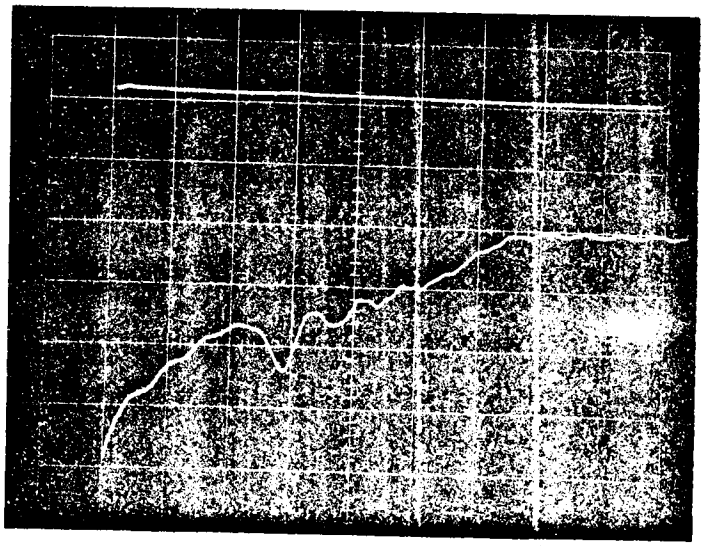
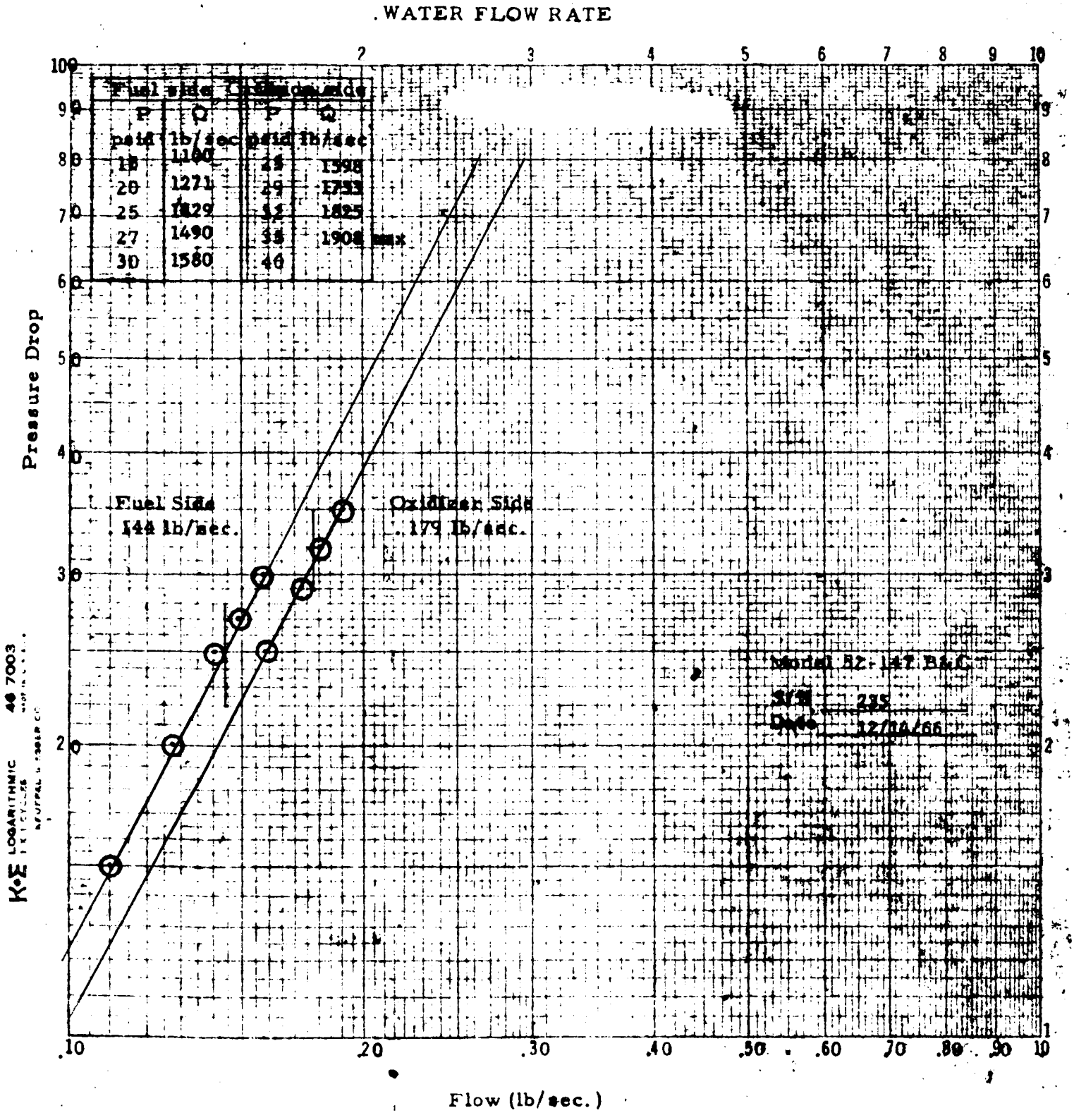


Primary On


WATER FLOW RATE
Fuel side
P psid
Q lb/sec
18 1100
20 1271
25 1629
27 1490
30 1580
Oxidizer side
P psid
Q lb/sec
45 1598
49 1733
52 1825
38 1908 max
46
Pressure Drop
Fuel Side
.144 lb/sec.
Oxidizer Side
.179 lb/sec.
Model B2-147 B&C
S/N 235
Date 12/14/66
Flow (lb/sec.)
K&E LOGARITHMIC 46 7003

MR 1152

Model 52-147 B, Serial No. 299
Test Data Check Off Sheet
Sheet 1 of 2

Moog Inc.
East Aurora, New York

TEST	PARA	LIMIT	VALUE
1. Examination of Product	3.2	a.) Conformance to external dimensions, markings, identification and finish.	Mark OK ok
		b.) Weight	Grams 787.5
2. Vibration test at 27.7 g rms	3.3	Min. Limit - 2 minutes	Vibration time 2.0 min
3. Valve Proof Pressure	3.4	No permanent set, distortion, or external leakage	Mark OK ok
4. Seat Assembly Proof Pressure	3.5	No permanent set, distortion, or external leakage	Mark OK ok
5. Dielectric Strength	3.6	.050 ma max	Pins to body 0.011 Between coils 0.010
6. Insulation Resistance	3.7	10^8 Megohms minimum	Pins to body 8,000 Between coils 40,000
7. Coil Resistance	3.8	Pin A to B (15±1.5 ohms) Pin C to Pin D (30±3.0 ohms)	Recorded Resistance 14.90 Coil Temperature 70 ° Resistance 14.77 Recorded Resistance 28.70 Coil Temperature 70 ° Resistance 28.51
8. Polarity Flow and Pressure Drop	3.9	Positive Signal Valve opens Fuel Side Pressure Drop Oxidizer Side Pressure Drop See attached plot	Mark OK ok psid(22 - 28) 25.50 psid(29 - 35) 32.75
9. Functional Test	3.10		

Coil Energized	Supply Pressure psig	Opening Voltage vdc	Limit vdc	Drop Out Voltage vdc	Limit vdc	Drop Out Current ma	Limit ma
Primary	465	10.4	≤16				
Secondary	345	12.1	≤16				
Primary	151			1.95	≥1.0	120	≥50.0
Secondary	151			3.09	≥1.0	108	≥30.0

Note any malfunctions during application of operating voltage at each Coil - Pressure - Voltage combination. None Allowed 0

Number of accumulated cycles (2000 minimum) 2000

Model 52-147 B, Serial No. 239 MR 1152

Test Data Check Off Sheet

Sheet 2 of 2

Moog Inc.
East Aurora, New York

TEST	PARA	LIMIT	VALUE
Response	3.11		

Coil Energized	Supply Pressure	Operating Current Amperes	Opening Time Sec.	Limits	Closing Time Sec	Limits
Primary	295		0.0070	< .009	0.0028	< .005
Secondary	560		0.0045	< .050	0.0024	< .005

Photographs attached

Flushing & Drying — 3.12 — (Completed) Mark ok — ok

External & cross port leakage — 3.13

Pressure applied to fuel side only, oxide side inlet and outlet open (<10^{-4} cc/sec) 2 x 10^{-7}

Pressure applied to oxide side only, fuel side inlet and outlet open (< 10^{-4} cc/sec) 3 x 10^{-6}

Internal leakage — 3.14

	Oxide Side		Fuel Side	
	First Check	Second Check	First Check	Second Check
50 psig	0.5	0.0	0.2	0.0
495 psig	0.2	0.2	0.2	0.0

< 1 cc/12 min at 50 psig

< 1.5 cc/12 min at 495 psig

Accumulated open close cycles — Total 4241

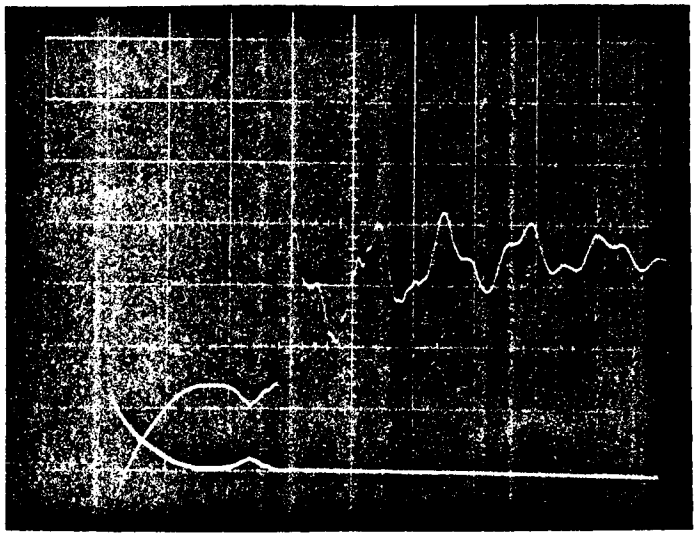
Accumulated energized time — Total 1 min 17 sec

Reverse seat leakage — 3.15 — < 3 cc/5 min Fuel 0.1 cc oxidizer — 0.2 cc

RESPONSE TIME

MODEL 52-147 B

S/N 239



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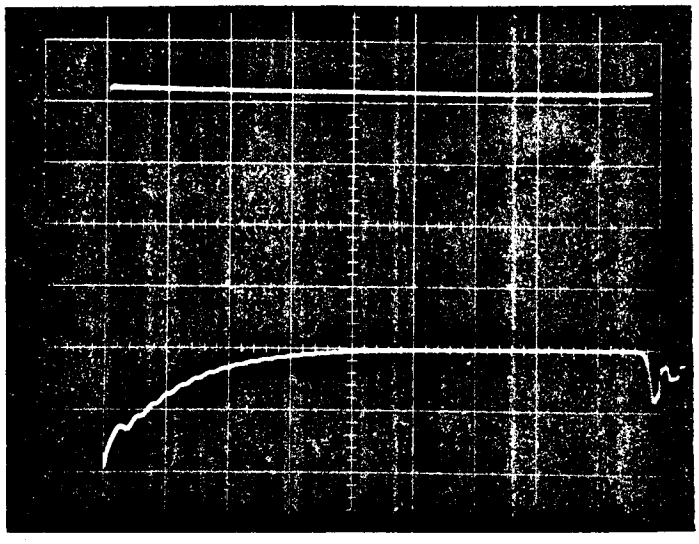

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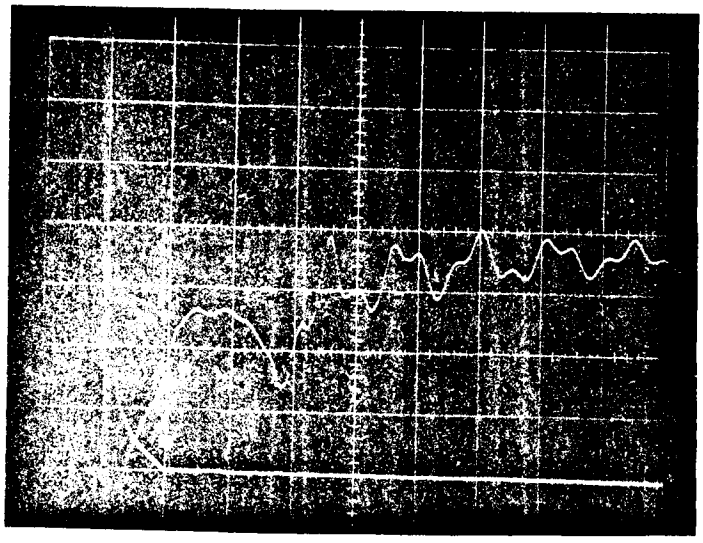

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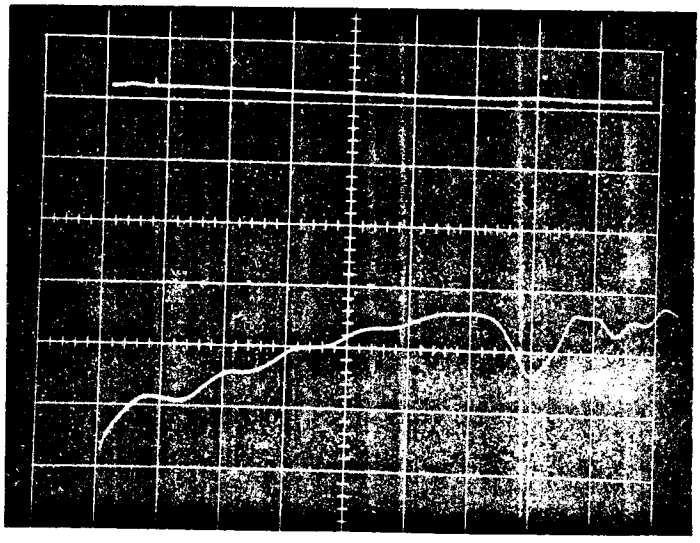
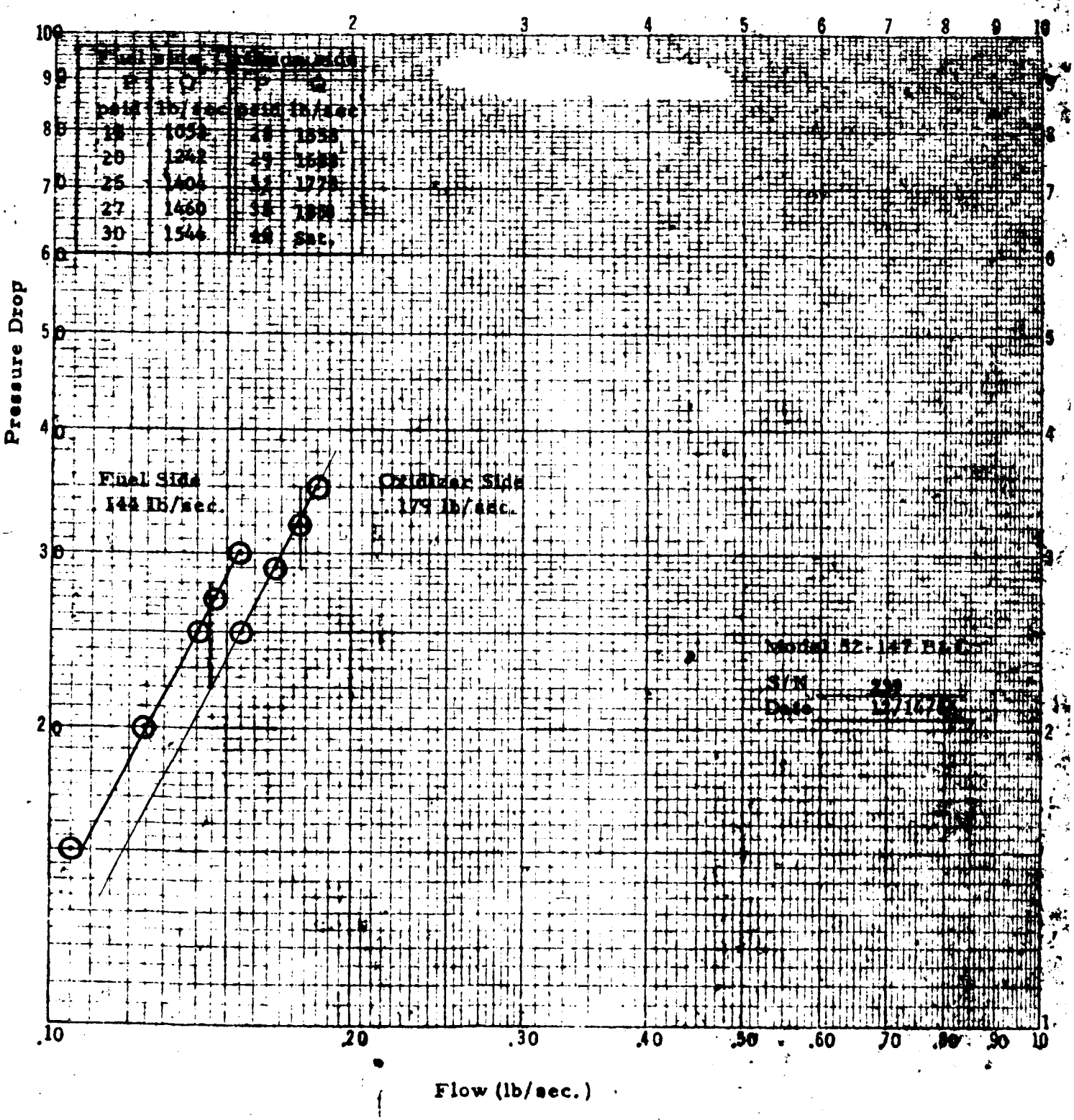


PRIMARY ON

WATER FLOW RATE



ACCEPTANCE TEST DATA

FOR

BIPROPELLANT CONTROL VALVE ASSEMBLY

Valve Model Number 52-147B
Valve Part Number 010-49029
Valve Serial Number 243

RMD Acceptance [signature]
Date 12-22-66

Moog QA Acceptance [signature]
Date 12 23 66

Government Inspector [signature]
Date 12/23/66

NOTE

The last MR revision affecting each page of this data booklet (page 17 through 20) is indicated in the upper right-hand corner of each of the following pages.

Model 52-147B , Serial No. 243
Test Data Check Off Sheet
Sheet 1 of 2

Moog Inc.
East Aurora, New York

TEST	PARA	LIMIT	VALUE
1. Examination of Product	3.2	a.) Conformance to external dimensions, markings, identification and finish.	Mark OK ok
		b.) Weight	Grams 789.5
2. Vibration test at 27.7 g rms	3.3	Min. Limit - 2 minutes	Vibration time 2.0 MIN.
3. Valve Proof Pressure	3.4	No permanent set, distortion, or external leakage	Mark OK ok
4. Seat Assembly Proof Pressure	3.5	No permanent set, distortion, or external leakage	Mark OK ok
5. Dielectric Strength	3.6	.050 ma max	Pins to body 0.009 Between coils 0.001
6. Insulation Resistance	3.7	100 Megohms minimum	Pins to body 4,000 Between coils 15,000
7. Coil Resistance	3.8	Pin A to B (15±1.5 ohms) Pin C to Pin D (30±3.0 ohms)	Recorded Resistance 14.90 Coil Temperature 74° Resistance 14.78 Recorded Resistance 29.0 Coil Temperature 74° Resistance 28.76
8. Polarity Flow and Pressure Drop	3.9	Positive Signal Valve opens Fuel Side Pressure Drop Oxidizer Side Pressure Drop See attached plot	Mark OK ok psid(22 - 28) 26.9 psid(29 - 35) 31.5
9. Functional Test	3.10		

Coil Energized	Supply Pressure psig	Opening Voltage vdc	Limit vdc	Drop Out Voltage vdc	Limit vdc	Drop Out Current ma	Limit ma
Primary	465	10.9	≤16				
Secondary	345	12.6	≤16				
Primary	151			1.38	≥1.0	89.0	≥50.0
Secondary	151			2.3	≥1.0	78.0	≥30.0

Note any malfunctions during application of operating voltage at each Coil - Pressure - Voltage combination. None Allowed none

Number of accumulated cycles(2000 minimum) 2000

MR 1152

Model 52-1478, Serial No. 243
Test Data Check Off Sheet
Sheet 2 of 2

Moog Inc.
East Aurora, New York

	TEST	PARA	LIMIT	VALUE

10 Response 3.11

Coil Energized	Supply Pressure	Operating Current Amperes	Opening Time Sec	Limits	Closing Time Sec	Limits
Primary	295		0.0048	< .009	0.0028	< .005
Secondary	360		0.031	< .050	0.0024	< .005

Photographs attached

11 Flushing & Drying 3.12 (Completed) Mark ok ok

12 External & Cross-port Leakage 3.13

Pressure applied to fuel side only, oxide side inlet and outlet open ($<10^{-4}$ cc/sec) 6.6×10^{-7}

Pressure applied to oxide side only, fuel side inlet and outlet open ($\leq 10^{-4}$ cc/sec) 4×10^{-6}

13 Internal Leakage 3.14

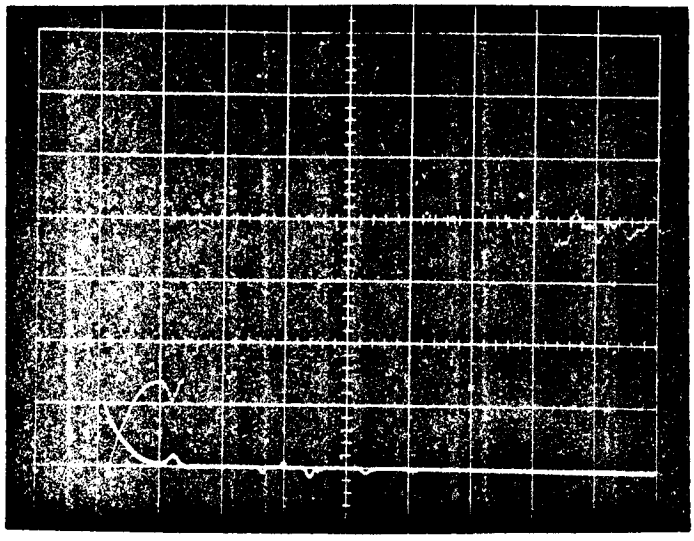
	Oxide Side		Fuel Side	
	First Check	Second Check	First Check	Second Check
50 psig	0.4	0.5	0.4	0.5
465 psig	0.1	0.2	0.3	0.1

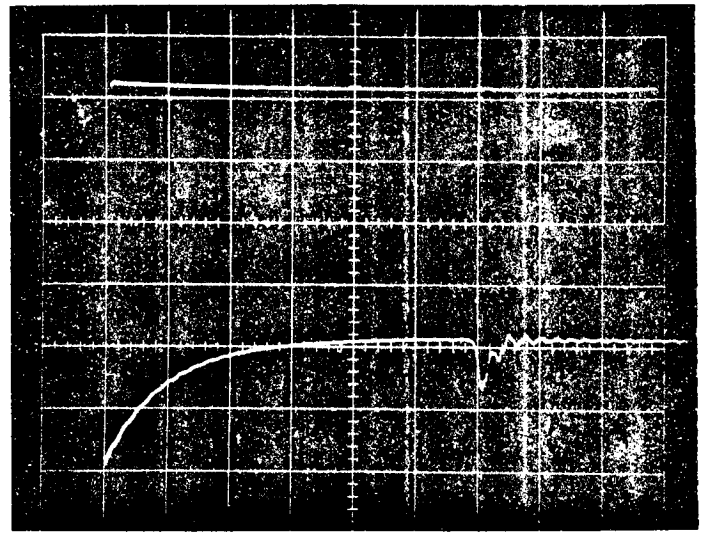
< 1 cc/12 min at 50 psig

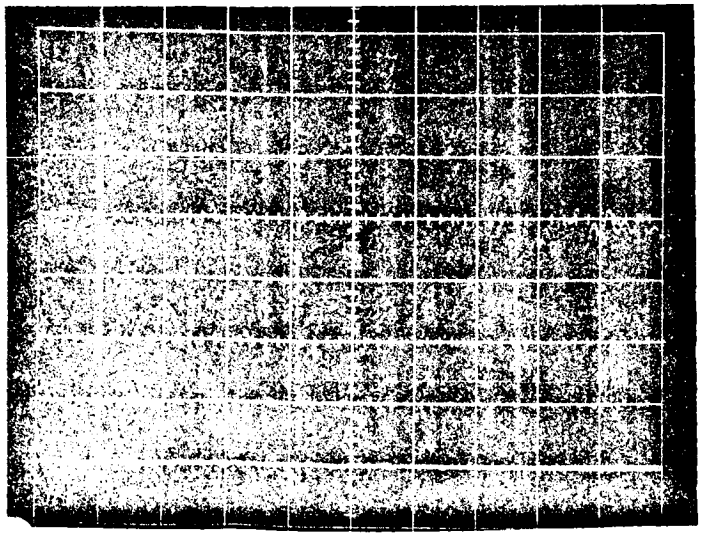
< 1.6 cc/12 min at 465 psig

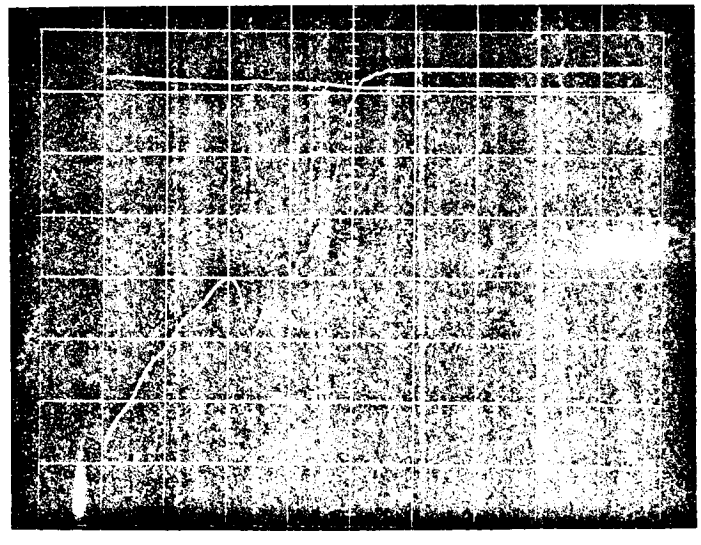
Accumulated open close cycles Total 4705
Accumulated energized time Total 1:22:00

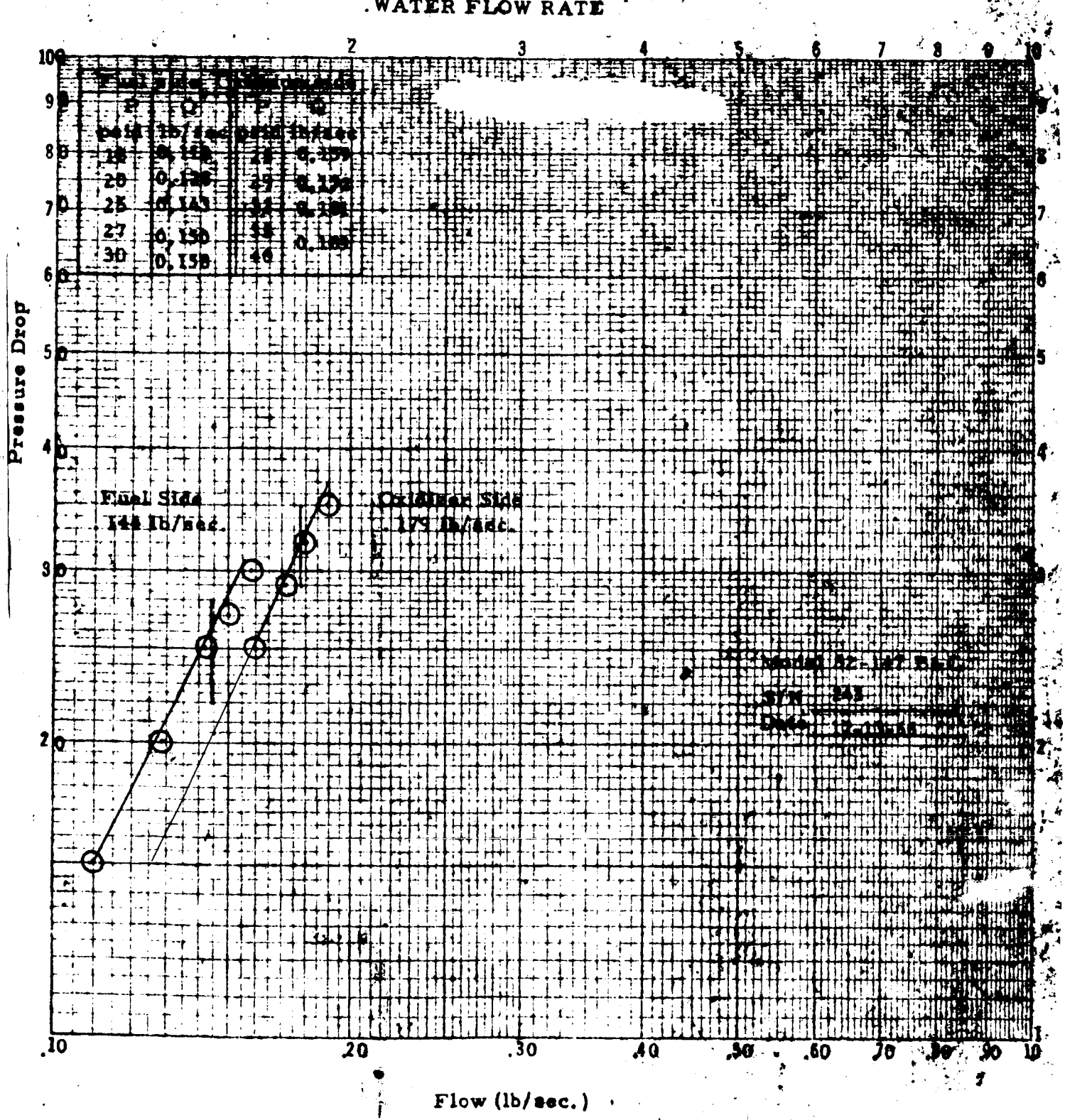
14 Reverse seat Leakage 3.15 ≤ 3 cc/6 min 0.9 0.8 cc










WATER FLOW RATE
Pressure Drop
Flow (lb/sec.)
Fuel Side
.148 lb/sec.
Oxidizer Side
.179 lb/sec.

ACCEPTANCE TEST DATA

FOR

BIPROPELLANT CONTROL VALVE ASSEMBLY

Valve Model Number 52-147B
Valve Part Number 010- 49029
Valve Serial Number 245
RMD Part Number 316305-300

RMD Acceptance [signature] (RMI 24)
Date 1/25/67

Moog QA Acceptance [signature] (Moog QA 6)
Date 1-26-67

Government Inspector [signature]
Date 1/26/67

NOTE

The last MR revision affecting each page of this data booklet (page 17 through 20) is indicated in the upper right-hand corner of each of the following pages.

Model 52-147 B, Serial No: 265
Test Data Check Off Sheet
Sheet 1 of 2

Moog Inc.
East Aurora, New York

TEST	PARA.	LIMIT	VALUE
1. Examination of Product	3.2	a.) Conformance to external dimensions, markings, identification and finish	Mark OK ok
		b.) Weight of unit	Pounds 1.7
2. Vibration test at 27.7 g rms	3.3	Min. Limit - 2 minutes	Vibration time 2.0 min.
3. Valve Proof Pressure	3.4	No permanent set, distortion, or external leakage	Mark OK ok
4. Seat Assembly Proof Pressure	3.5	No permanent set, distortion, or external leakage	Mark OK ok
5. Dielectric Strength	3.6	.050 ma max	Pins to body 0.010 Between coils 0
6. Insulation Resistance	3.7	100 Megohms minimum	Pins to body 30,000 Between coils 170,000
7. Coil Resistance	3.8	Pin A to B (154±1.5 ohms)	Resistance 14.885
		Pin C to Pin D (30±3.0 ohms)	Resistance 28.676
8. Polarity Flow and Pressure Drop	3.9	Positive Signal Valve opens Fuel Side Pressure Drop Oxidizer Side Pressure Drop See attached plot	Mark OK ok psid(22 - 28) 26.7 psid(29 - 35) 30.2
9. Functional Test	3.10		

Coil Energized	Supply Pressure psig	Opening Voltage vdc	Limit vdc	Drop Out Voltage vdc	Limit vdc	Drop Out Current ma	Limit ma
Primary	360	7.3	≤20				
Secondary	360	11.6	≤20				
Primary	166			2.3	≥1.0	140	≥50.0
Secondary	166			3.5	≥1.0	113	≥30.0

Note any malfunctions during application of operating voltage at each Coil - Pressure - Voltage combination. None Allowed: none

Number of accumulated cycles (2000 minimum): 2,000

Model 52-147 B, Serial No. 245
Test Data Check Off Sheet
Sheet 2 of 2

MR 1152
Rev. A
Moog Inc.
East Aurora, New York

	TEST	PARA	LIMIT	VALUE
10	Response	3.11		

Coil Energized	Supply Pressure	Operating Current Amperes	Opening Time Sec	Limits	Closing Time Sec	Limits
Primary	310		0.0068	< .009	0.0028	< .005
Secondary	360		0.023	< .050	0.0024	< .005

Photographs attached

11	Flushing & Drying	3.12	(Completed)	Mark ok	ok
12	External & Cross-port Leakage	3.13	Pressure applied to fuel side only, oxide side inlet and outlet open (<10^{-4} cc/sec)		4×10^{-7}
			Pressure applied to oxide side only, fuel side inlet and outlet open (≤ 10^{-4} cc/sec)		3.8×10^{-7}
13	Internal Leakage	3.14			

	Oxide Side		Fuel Side	
	First Check	Second Check	First Check	Second Check
50 psig	0	0	0	0
360 psig	0	0	0	0

< 1 cc/12 min at 50 psig

< 1.6 cc/12 min at 360 psig

14	Reverse seat Leakage	3.15	≤ 3 cc/6 min	oxidizer 0 cc	Fuel 0 cc

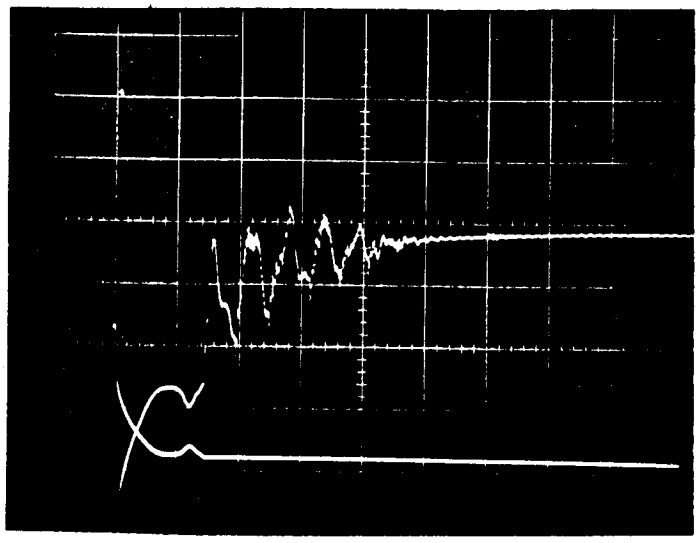
Wet --- Accumulated open close cycles Total 4118
Dry --- Accumulated open close cycles Total 112

Accumulated energized time Total 2:06 45

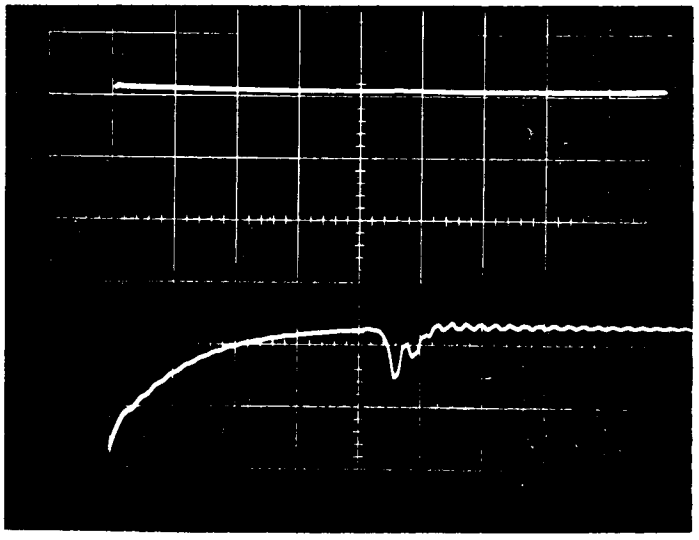
RESPONSE TIME

MODEL 52-147 B

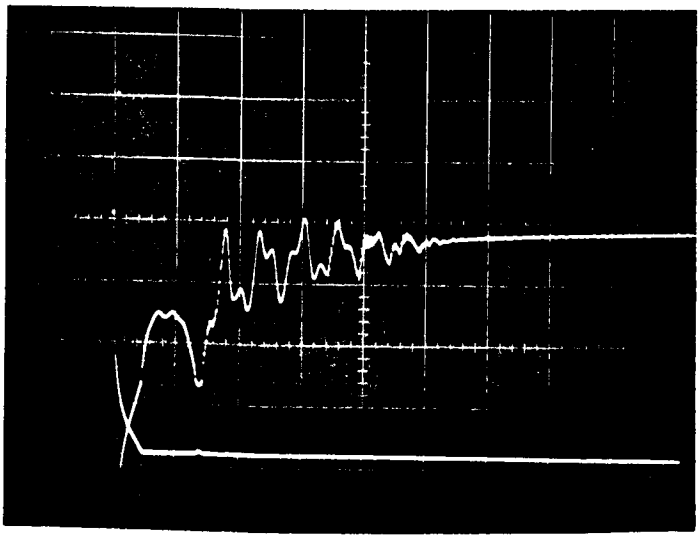
S/N 245



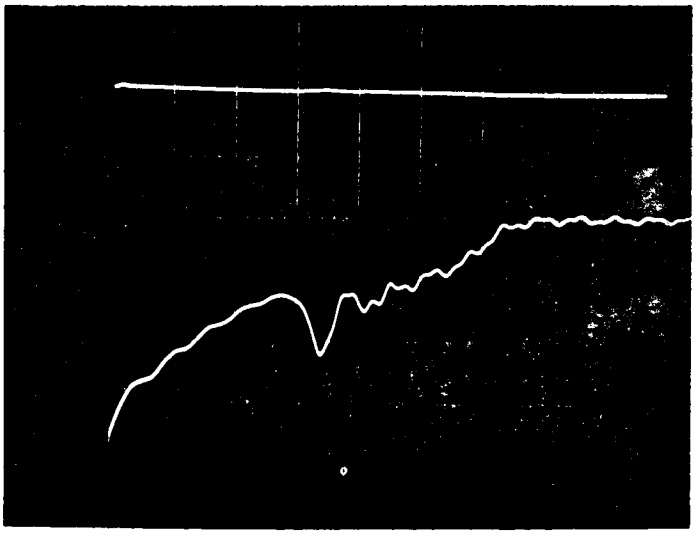
SECONDARY OFF



SECONDARY ON

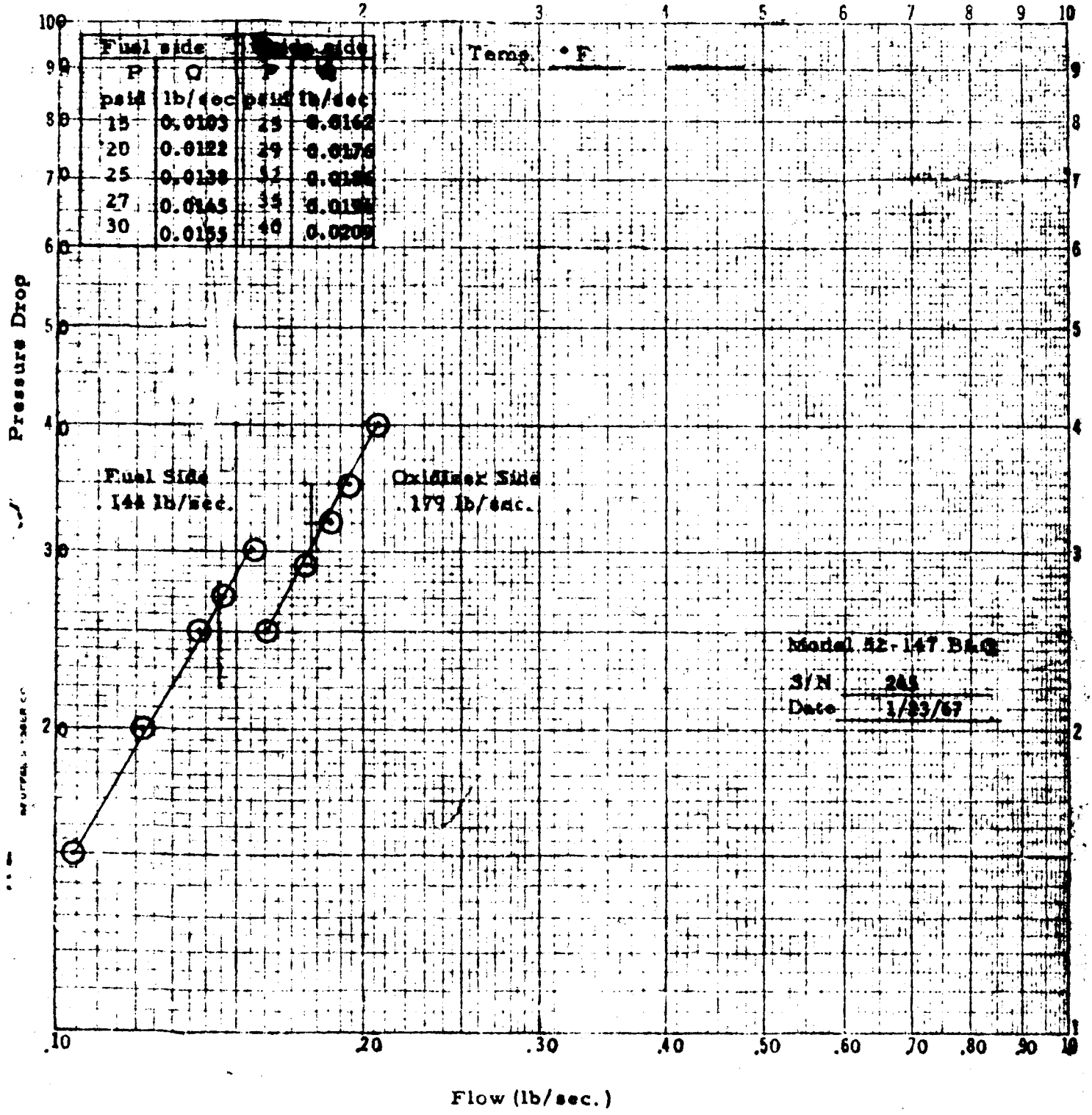


PRIMARY OFF



PRIMARY ON

WATER FLOW RATE



ACCEPTANCE TEST DATA

FOR

BIPROPELLANT CONTROL VALVE ASSEMBLY

Valve Model Number 52-147 B
Valve Part Number 010- 49029
Valve Serial Number 266
RMD Part Number 316305- 209

RMD Acceptance W. Longo
Date 4-28-67

Moog QA Acceptance C. Pittendorf
Date 4-25-67

Government Inspector
Date

NOTE

The last MR revision affecting each page of this data booklet (page 17 through 20) is indicated in the upper right-hand corner of each of the following pages.

Model 52-147 B, Serial No. 266
Test Data Check Off Sheet
Sheet 1 of 2

Moog Inc.
East Aurora, New York

TEST	PARA	LIMIT	VALUE
1. Examination of Product	3.2	a.) Conformance to external dimensions, markings, identification and finish.	Mark OK ok
		b.) Weight of unit	Pounds 1.74
2. Vibration test at 27.7 g rms	3.3	Min. Limit - 2 minutes	Vibration time 2:00
3. Valve Proof Pressure	3.4	No permanent set, distortion, or external leakage	Mark OK ok
4. Seat Assembly Proof Pressure	3.5	No permanent set, distortion, or external leakage	Mark OK ok
5. Dielectric Strength	3.6	.050 ma max	Pins to body 0.006 Between coils 0.001
6. Insulation Resistance	3.7	100 Megohms minimum	Pins to body 3,000 Between coils 15,000
7. Coil Resistance	3.8	Pin A to B (15±1.5 ohms)	Resistance 14.84
		Pin C to Pin D (30±3.0 ohms)	Resistance 28.71
8. Polarity Flow and Pressure Drop	3.9	Positive Signal Valve opens Fuel Side Pressure Drop Oxidizer Side Pressure Drop See attached plot	Mark OK ok psid(22 - 28) 25.2 psid(29 - 35) 31.5
9. Functional Test	3.10		

Coil Energized	Supply Pressure psig	Opening Voltage vdc	Limit vdc	Drop Out Voltage vdc	Limit vdc	Drop Out Current ma	Limit ma
Primary	360	7.9	<20				
Secondary	360	12.8	<20				
Primary	166			2.1	>1.0	128.0	>50.0
Secondary	166			3.3	>1.0	107.0	>30.0

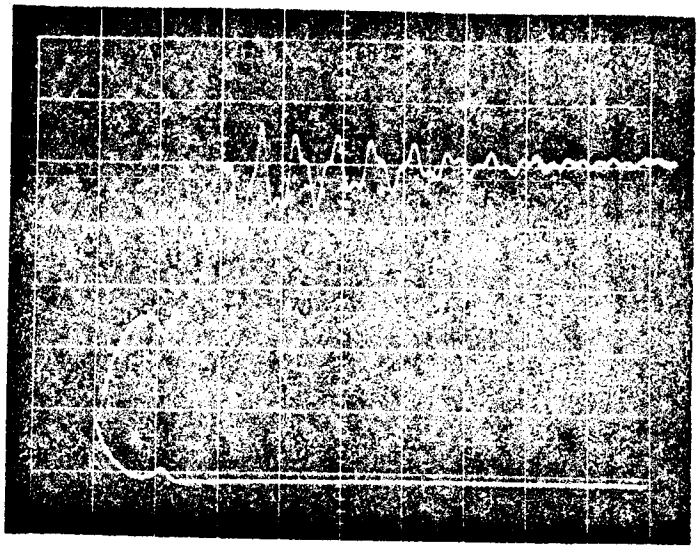
Note any malfunctions during application of operating voltage at each Coil - Pressure - Voltage combination None Allowed none

Number of accumulated cycles(2000 minimum) 2000

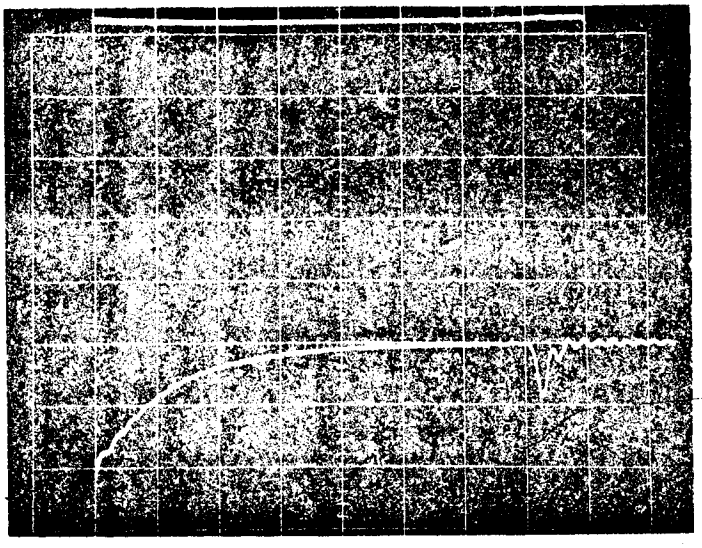
RESPONSE TIME

MODEL 52-147 B

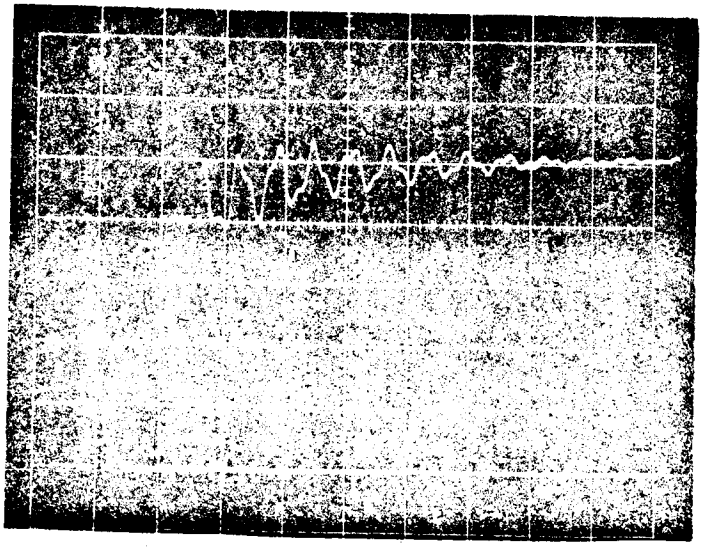
S/N 266



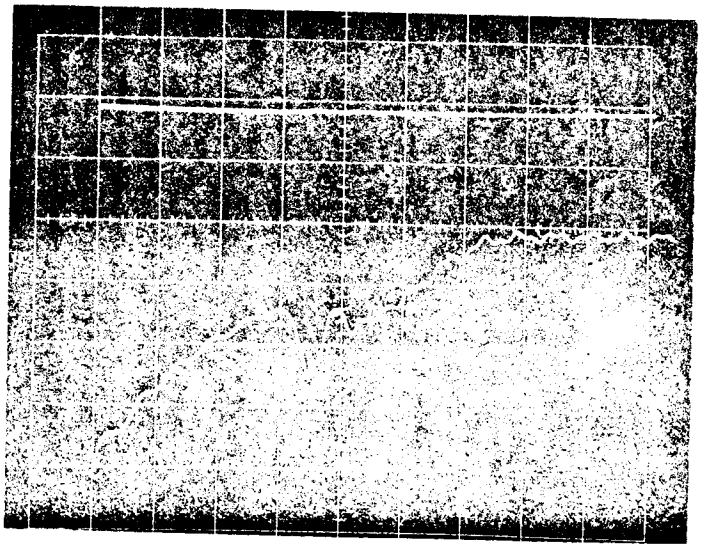
Secondary Off



Secondary On



Primary Off



Primary On

Model 52-147 h, Serial No. 266
Test Data Check Off Sheet
Sheet 2 of 2

MR 1152
Rev. A
Moog Inc.
East Aurora, New York

	TEST	PARA	LIMIT	VALUE
10	Response	3.11		

Coil Energized	Supply Pressure	Operating Current Amperes	Opening Time Sec	Limits	Closing Time Sec	Limits
Primary	310		0.0070	< .009	0.0026	< .005
Secondary	360		0.036	< .050	0.0022	< .005

Photographs attached

11	Flushing & Drying	3.12	(Completed)	Mark ok	ok
12	External & Cross-port Leakage	3.13	Pressure applied to fuel side only, oxide side inlet and outlet open (<10^{-4} cc/sec)		1.5×10^{-6}
			Pressure applied to oxide side only, fuel side inlet and outlet open (≤ 10^{-4} cc/sec)		3.13×10^{-6}
13	Internal Leakage	3.14			

	Oxide Side		Fuel Side	
	First Check	Second Check	First Check	Second Check
50 psig	0.0	0.0	0.3	0.4
360 psig	0.0	0.0	0.0	0.0

< 1 cc/12 min at 50 psig

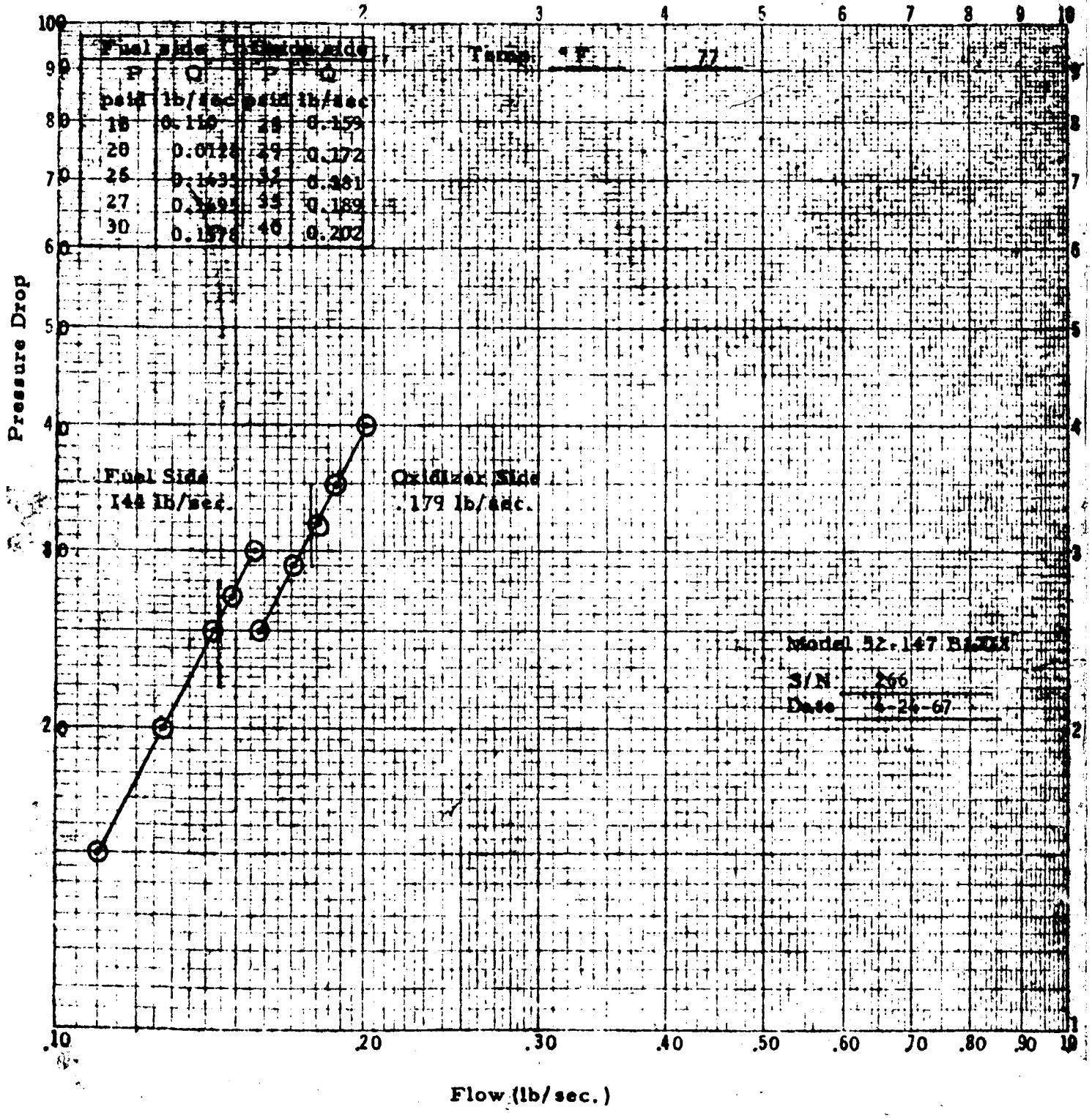
< 1.6 cc/12 min at 360 psig

14	Reverse seat Leakage	3.15	≤ 3 cc/6 min	Fuel 0.0 cc	Oxidizer 0.0 cc

Wet --- Accumulated open-close cycles Total 135
Dry --- Accumulated open-close cycles Total 4327

Accumulated energized time Total 1Hr 33Min 45Sec

WATER FLOW RATE



Fuel Side		Oxidizer Side	
P psid	Q lb/sec	P psid	Q lb/sec
18	0.110	28	0.159
20	0.0726	29	0.172
26	0.1431	32	0.181
27	0.1491	35	0.189
30	0.1576	40	0.202

ACCEPTANCE TEST DATA

FOR

BIPROPELLANT CONTROL VALVE ASSEMBLY

Valve Model Number 52-147 B
Valve Part Number 010-49029
Valve Serial Number 239

RMD Acceptance
Date 12-29-66

Moog QA Acceptance
Date 12-29-66

Government Inspector
Date 12/29/66

NOTE

The last MR revision affecting each page of this data booklet (page 17 through 20) is indicated in the upper right-hand corner of each of the following pages.

Thiokol
REACTION MOTORS DIVISION

APPENDIX K

QUADREDUNDANT VALVE ASSEMBLY

RMD SPECIFICATION EC20518

SPEC. EC20518

Thiokol CHEMICAL CORPORATION
REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

SPECIFICATION EC20518

CLASS II | PG. 1 OF 51 | LET. J

TITLE QUADREDUNDANT VALVE ASSEMBLY, DETAIL SPECIFICATION FOR

PURPOSE This specification defines the requirements of a four-passage, pulse modulated, valve for control of a stabilization and attitude control rocket engine employed for spacecraft.

LET.	REL. No.	DATE	PAR.	CHANGE	CHK.	APP.	
A	6204-687	3/4/66		For Changes See C.N. 6204-687			
B	6204-1490	6/17/66		For changes see A.C. 6204-1490			
C	6204-2192	9/28/66		For changes see A.C. 6204-2192			
D	6204-2319	10/6/66		For changes see A.C. 6204-2319			
E	6204-2563	11/9/66		For changes see A.C. 6204-2563			
F	6204-2838	12/21/66		For Changes See A.C. 6204-2838			
G	6204-3302	5/10/67		For Changes See A.C. 6204-3302			
H	6204-3360	5/16/67		For Changes See A.C. 6204-3360			
J	6204-3572	6/14/67		For Changes See A.C. 6204-3572			

ORIG	Eng Chg	Design	S&C	Mfg.	Q.C.	Reliab.	REL. NO.
							6204-
11/23/65		12-1-65		10-30-65	11-30-65	12-1-65	47

RMD RE 33C

1.0 SCOPE

1.1 Scope - This specification describes the requirements for a pulse modulated, torque motor operated, propellant valve assembly which provides series-parallel flow paths and redundant valves in each propellant passage. The valve is used for control of a stabilization and attitude control rocket engine for spacecraft.

2.0 APPLICABLE DOCUMENTS

2.1 The following documents, of the issue specified in RMD Specification 44882 on the date of invitation for bid, shall form a part of this specification to the extent specified herein. In the case of conflict between this specification and referenced specifications, the requirements of this specification shall apply.

2.1.1 Specifications

2.1.1.1 Military

MIL-A-8625 Anodic Coatings for Aluminum and Aluminum alloys

MIL-B-5087 Bonding, Electrical

MIL-D-70 327 Drawings, Engineering and Associated Lists

2.1.1.1 Military (continued)

MIL-I-6181	Interference Control Requirements, Aircraft Equipment
MIL-I-6866	Inspection, Penetrant Method of
MIL-P-26539	Propellant, Nitrogen Tetroxide
MIL-P-27404	Propellant - Monomethylhydrazine
MIL-M-9868	Microfilming of Engineering Documents, 35MM, Requirements for
MIL-S-7742	Screw Thread, Standard Aeronautical
MIL-W-8160	Wiring, Guided Missile, Installation of, General Specification for

2.1.1.2 NASA

MSFC Spec 202	Compound, Potting and Molding, Elastomeric Specification for
MSFC Spec 250	Protective Finishes for Space Vehicle Structures and Associated Flight Equipment, General Specification for
MSFC Spec 222	Resin Systems, Electrical and Environmental Insulation, Epoxy

2.1.1.3	RMD	
	RMD 7145	Identification of Parts and Assemblies
	RMD 403-1	Quality Control Requirements for Suppliers
	RMD 44883	Applicable Documents, C-1 Program
2.1.2	Procedures	
2.1.2.1	NASA	
	NPC-200-4	Soldering of Electrical Connections (High Reliability) Procedure for
2.1.3	Standards	
2.1.3.1	Military	
	MS 33540	Safety Wiring, General Practice
	NAS-50	Rings, Internal Retaining
	NAS-51	Rings, Internal Retaining
	JAN-B-121	Barrier, Materials, Greaseproof
	AN 995	Wire, Lock
	MIL-STD-810	Environmental Test Methods for Aerospace and Ground Equipment

2.1.4 Drawings

2.1.4.1 Military

MS 33586	Metals, Definition of Dissimilar

2.1.4.2 NASA

MSFC Drawing 10M0171	Environmental Protection When Using Electrical Equipment Within the Areas of Saturn Complexes Where Hazardous Areas Exist, Procedure for
MSFC Drawing 10M30111	Failure Mode and Effect Analysis
MSFC Specification 135	Welding, Fusion, Specification for

2.1.4.3 THIOKOL - RMD

317031	Switch, Response, Quadredundant Valve
55-1043-36	Lubricant

3.0 REQUIREMENTS

3.1 Qualification . Quadredundant valves procured to this specification require qualification in accordance with paragraph 4.0 and approval of the test report by the purchaser..

3.2 Design and Construction

3.2.1 General Design Features - Components procured to this specification shall be constructed to withstand the strains, jars, vibrations, and other conditions incidental to shipping, storage, installation handling and service use.

3.2.1.1 Center of Gravity and Moment of Inertia. Component center of gravity and moment of inertia are critical to the balance and dynamic characteristics of the vehicle in which this component is installed. The center of gravity location and values of the moments of inertia about three orthogonal axes through their centers of gravity (one being parallel to the longitudinal axis) shall be specified on the drawings submitted by the vendor and the maximum tolerance variations (both plus and minus) shall be indicated. The tolerance shall be the minimum possible and is subject to approval by the purchaser.

3.2.1.2 Valve Volume. The valve cavities shall minimuze fluid entrapment in any installed attitude and shall maximize fluid removal by dry gas purging. The volume between the downstream valve seats and the outlet face of the valve shall not exceed .054 in^3 for the fuel side and .077 in^3 for the oxidizer side of the valve. The vendor's drawing shall state the actual volumes upstream, between and downstream of the four valves in each valve assembly.

3.2.1.3 Torque Motor. Each torque motor shall provide a means of leak testing its flexure tube by having removable cover. Each cover shall be sealed with a teflon gasket and coil lead wire egress shall be sealed by potting.

3.2.1.3.1 Coil Temperature Limits. - The temperature rise and final temperature of each coil as measured by monitoring current and voltage shall be within the limiting temperatures of the thermal classification of the coil wire used. The insulation classification of the coils shall be specified on the vendor's drawings and shall be subject to the purchaser's approval.

3.2.2 Selection of Specifications and Standards. - The specifications used for the processes that may affect performance or durability of the valve shall be selected from paragraph 2.1 or shall be prepared as required.

3.2.3 Materials, Parts, and Processes. - Materials used for the manufacture of components procured to this specification shall be of high quality, and suitable for the purpose. All materials and processes used shall conform to applicable government specifications. Use of specifications and standards other than these is subject to approval by the purchaser.

3.2.3.1 Plastic Parts. - The use of plastic parts shall be subject to the purchaser's approval. Where plastics or other synthetic materials are used, the vendor shall control physical and chemical properties as required to ensure a uniform material. The materials used shall be compatible with space vacuum.

3.2.3.2 Seals. Teflon coated metal seals or welded joints shall be used to externally seal all propellant passages. Selection of seal design and material choice shall be subject to purchaser approval.

3.2.3.3 Ceramic/Refractory Materials. Ceramic or refractory materials, if used in the valve, shall not crack or break at any time whether operating or nonoperating and under any combination of the environments and operating conditions specified herein.

3.2.3.4 Safetying. All threaded parts shall be positively locked or safetied by safety-wiring, self-locking nuts, or other approved methods. Safety-wiring shall be applied in accordance with the practice outlined in Standard MS33540, and shall conform to Drawing AN995.

3.2.3.5 Lubricants. PR-240-C Fluorocarbon Grease (RMD P/N 55-1043-36) manufactured by E.I. DuPont DeNemours and Co., Wilmington, Delaware or Brayco Grease (RMD P/N 55-1043-35) Propellant Compatable, Frankford Arsenal Formula PD 817 shall be the only lubricants used.

3.2.3.6 Filtration. Filters shall be installed upstream of the oxidizer and fuel seats. These filter elements shall retain 98 percent of all particles of which the two smallest orthogonal dimensions are greater than 40 microns in the fuel passages and 20 microns in the oxidizer passages.

3.2.3.7 Alignment. Not applicable.

3.2.3.8 Description. The assembly shall consist of two valve bodies, one oxidizer and one fuel. Each body shall provide for a series-parallel flow path through the integral four valve assemblies. Each valve shall be actuated by a single torque motor. Each valve body shall have a bleed port located between its inlet port and first set of shut-off valves. The two bleed ports are required for venting during "fill" operations to insure that the passages get filled with liquid propellants.

3.2.3.9 Threads. Only straight threads conforming to specification MIL-S-7742, National Fine Thread Series Class 2 (NF2) or unified thread series classes 2A or 2B shall be used, except when a subsequent seal weld is utilized. Tapered pipe-threads are specifically prohibited.

3.2.3.10 Electrical Design. Details of the electrical design shall minimize the possibility of explosion in an atmosphere of oxygen and hydrogen gases in accordance with MSFC-Dwg-10M0171. Electrical components shall comply with the following.

3.2.3.10.1 Wiring. All electrical wiring shall comply with MIL-W-8160, and shall be compatible with the environments of this specification. Silver plated wire is not acceptable. The leads from each coil shall consist of two wires (provision for a valve signature trace shall be provided at the valve connector) and each set of two leads shall be bundled and shielded to produce a total of 8 shields for the 16 leads. The lead length and required connector shall be specified on the specification control drawing (SCD).

3.2.3.10.2 Insulation Resistance. The insulation resistance shall be greater than 100 megohms at 500 vdc ± 50 vdc.

3.2.3.10.3 Potting. Potting of electrical components shall be in accordance with MSFC-Spec-202 and MSFC-Spec-222 or as approved by the purchaser. The compound must be compatible with the envirmonments of this specification.

3.2.3.10.4 Dielectrical Strength. - Insulation must withstand a potential of 1000 VAC RMS at 60 cps, applied for one (1) minute between all current carrying parts one to another and to grounded metal parts. The vendor shall specify the number of tests permitted and report the number performed.

3.2.3.10.5 Bonding. - Bonding of all parts shall be in accordance with MIL-B-5087.

3.2.3.10.6 Interference. - The valve shall meet the requirements of MIL-I-6181, paragraph 4.3.2, 4.3.4, 4.3.4.1, 4.3.4.1.1 (but not 4.3.4.1.2), 4.3.4.2 and 4.3.4.3.

3.2.3.10.7 Corona Discharge. - All electrical components shall not exhibit corona discharge while operating in a vacuum of 10^{-9} mmHg

3.2.3.10.8 Soldering. - Solder, preparation for soldering and soldering of electrical connections shall conform to NPC-200-4.

3.2.4 Standard and Commercial Parts. - Standard parts (MS, AN or JAN) shall be used unless determined by the manufacturer to be unsuitable and shall be identified on the component drawing by their standard part numbers. In the event that there is not a suitable standard part, a commercial part may be used subject to purchaser's approval, provided it conforms to all applicable requirements of this specification.

3.2.4.1 Special Tools. - A detailed description of any tools, or special techniques required for the disassembly, assembly or adjustment of the valve shall be so noted on the vendor's drawing(s). Special tools, if required, shall be identified by an appropriate part number. Special maintenance, repair, tools, or assembly descriptions may be prepared as supplementary specifications to the drawing(s) if desired and if properly cross referenced with the drawing(s).

3.2.5 Moisture and Fungus Resistance. - Materials which are not nutrients for fungi shall be used to the greatest extent practicable. Where materials that are nutrients for fungi must be used, such materials shall be treated with fungicidal agents.

3.2.6 Corrosion of Metal Parts. - Metals shall be of a corrosion-resisting type or suitably protected against corrosion from atmospheric elements, propellants (3.3.2), and flushing fluids (3.10).

3.2.6.1 Dissimilar Metals. - Unless suitably protected against electrolytic corrosion as specified in MSFC-Spec-250, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in Drawing MS 33586.

3.2.6.2 Aluminum-Alloy Parts. - Unless otherwise authorized, all aluminum alloy parts shall be covered with an anodic film conforming to the requirements of Specification MIL-A-8625.

3.2.7 Interchangeability. - All assemblies having the same manufacturer's part number shall be directly and completely interchangeable with each other with respect to installation, weight, and performance.

3.2.8 Identification and Marking

3.2.8.1 Port Identification. - The ports shall be identified to indicate direction of flow and propellant. The identification shall be clearly visible in the base material.

3.2.9 Storage Life. - The valve shall suffer no detrimental effects when stored in the dry condition at temperatures between minus 65F and plus 160F for a period of five (5) years.

3.3 Performance.

3.3.1 Flow Characteristics. - The relationship between pressure drop and flow rate for the two propellant passages shall be as follows:

	Fuel	Oxidizer
Rated Flow (lb/sec)	0.133	0.213
Propellant Flow Temperature	120F	70F

3.3.1 Flow Characteristics. - (continued)

	Fuel	Oxidizer
Equivalent Water Flow (lb/sec)	0.144	0.179
Water Flow Temperature	80F	80F
Inlet Pressure (psig)	195	195
Maximum Pressure Drop (psi)		
Two paths open	11	14
One path open	31	40

3.3.2 Propellants

(a) Fuel. - Monomethylhydrazine (MMH) in accordance with MIL-P-27404.

(b) Oxidizer. - Nitrogen Tetroxide (N_2O_4) in accordance with MIL-P-26539.

3.3.3 Static Performance

3.3.3.1 Normal Working Pressure. - 195 psia

3.3.3.2 Working Pressure

3.3.3.2.1 Rated Pressure. - The rated pressure range shall be 180 psia minimum to 212 psia maximum.

3.3.3.2.2 Operating Pressure. - The operating pressure range shall be 166 psia minimum to 325 psia maximum.

3.3.3.3 Proof Pressure. - Valve Assembly - 720 psig
Seat Assembly - 720 psig

3.3.3.4 Burst Pressure. - 1150 psig

3.3.3.5 Pressure Spikes. - The valve shall be capable of withstanding peak pressures generated by ignition peak pressures or dynamic fluid surges as follows:

(a) Ignition back pressures of 1150 psig applied for one (1) millisecond (1,000,000 psi/sec) for 50,000 cycles.

(b) Dynamic fluid pressure (water hammer) of 720 psig at a frequency of 600 cps.

3.4 Environment. - The valve shall suffer no detrimental effects and shall operate within specification limits during or after exposure to the environmental extremes as defined in this specification and in MIL-STD-810.

3.4.1 Operating Temperatures

3.4.1.1 Ambient Temperature. - The valve shall be capable of operation at any environmental temperature between + 12F and +180F at sea level or any altitude. The valve shall be capable of withstanding a maximum temperature of 250F during non-operating periods.

3.4.1.2 Propellant Temperature. - The maximum propellant temperatures upstream of the valve seat shall be 171F oxidizer and 275F fuel. Capability of 340F fuel temperature shall be a design goal.

3.4.2 Heat Transfer. - Deleted

3.4.3 Ambient Atmosphere. - The physical and operational characteristics of the valve shall not be deteriorated by 346 hours of exposure to space vacuum of 10^{-12} psia.

3.4.4 Ambient Pressure. - 10^{-12} psia to 15 psia

3.4.5 Attitude. - Any attitude.

3.4.6 Vibration. - The valve shall operate within specification limits after exposure to the following vibration conditions, both non-operating and operating, while assembled as part of the Thiokol-RMD part number 318000-200 Rocket Engine, Spacecraft (RES). The vibration inputs shall be applied to the RES mounting surface while the RES is either pressurized or unpressurized as specified in the following paragraphs. There shall be no liquid leakage of the pressurized valve during vibration. After vibration, the valve shall meet the dry gaseous leakage requirements of paragraph 3.5.

3.4.6.1 Non-Operating Vibration. - Apply the following vibration inputs to the dry, unpressurized valve - RES assembly in each of three mutually perpendicular axes.

3.4.6.1.1 Sinusoidal Vibration. - Sweep the frequency range, logarithmically, at the rate of 1.0 octave per minute from 5 H_Z to 2000 H_Z and back to 5 H_Z at the following input levels.

5 to 20 H_Z at 0.19 inch D.A. displacement
20 to 150 H_Z at 4.0 g's peak
150 to 2000 H_Z at 2.0 g's peak
The minimum rate of decrease at 150 H_Z shall be 60 decibels per octave.

3.4.6.1.2 Random Vibration. - Subject the test specimen to 5 minutes per axis random excitation at the following input levels.

20 to 100 H_z	- constant at	.137 g^2/H_z
100 to 200 H_z	decrease at	6.0 db/octave
200 to 700 H_z	constant at	.034 g^2/H_z
700 to 2000 H_z	- decrease at	6.0 db/octave

3.4.6.2 Operating Vibration. - Apply the following vibration inputs to the liquid filled pressurized valve - RES assembly in each of three mutually perpendicular axes. The RES inlets shall be pressurized to 166 psig during the test.

3.4.6.2.1 Sinusoidal Vibration. - Sweep the frequency range, logarithmically, at a rate of 1.0 octave per minute from 5 H_z to 2000 H_z and back to 5 H_z at the following input levels:

5 to 57 H_z	at 0.0085 inch D.A. displacement
57 to 150 H_z	at 1.4 g's peak
150 to 300 H_z	at 0.0012 inch D.A. displacement
300 to 2000H_z	at 5.5 g's peak

3.4.6.2.2 Random Vibration. - Subject the test specimen to 9 minutes per axis random excitation at the following input levels:

20 to 260 H_z	- linear increase on log-log coordinates from 0.003 g^2/H_z to 0.039 g^2/H_z
260 to 1000 H_z	- constant at 0.039 g^2/H_z
1000 to 2000 H_z	- linear decrease on log-log coordinates from 0.039 g^2/H_z to 0.015 g^2/H_z

3.4.6.3 Design Goal Vibration. - As a design goal, the valve shall operate within specification limits after exposure to the following vibration conditions, both non-operating and operating, while assembled as part of the Thiokol-RMD Part Number 318000-200 Rocket Engine, Spacecraft (RES). The vibration inputs shall be applied to the RES mounting surface while the RES is filled with liquid and pressurized to 166 psig. There shall be no valve liquid leakage during vibration. After vibration, the valve shall meet the dry gaseous leakage requirements of paragraph 3.5.

3.4.6.3.1 Non-Operating Vibration. - Apply the following vibration inputs to the valve-RES assembly in each of three mutually perpendicular axes.

3.4.6.3.1.1 Sinusoidal Vibration. - Sweep the frequency range, logarithmically, at a rate of 1.0 octave per minute from 5 H_z to 2000 H_z and back to 5 H_z at the following input levels:

5 to 58 H_z at 0.031 inch D.A. displacement
58 to 150 H_z at 5.4 g's peak
150 to 295 H_z at 0.0049 inch D.A. displacement
295 to 2000 H_z at 21.8 g's peak

3.4.6.3.1.2 Random Vibration. - Subject the test specimen to 12 minutes of random excitation at the following input levels:

10 to 110 H_z - 0.055 g^2/Hz increasing at 3 decibels per octave to 0.62 g^2/H_z
110 to 1000 H_z - constant at 0.62 g^2/H_z
1000 to 2000 H_z - linear decrease on log-log coordinates to 0.055 g^2/H_z at 2000 H_z

3.4.6.3.2 Operating Vibration. - Apply the following vibration inputs to the valve-RES assembly in each of three mutually perpendicular axes.

3.4.6.3.2.1 Sinusoidal Vibration. - Sweep the frequency range, logarithmically, at a rate of 1.0 octave per minute from 5 H_z to 2000 H_z and back to 5 H_z at the following input levels:

5 to 57 H_z at 0.0085 inch D.A. displacement
57 to 150 H_z at 1.4 g's peak
150 to 300 H_z at 0.0012 inch D.A. displacement
300 to 2000 H_z at 5.5 g's peak

3.4.6.3.2.2 Random Vibration. - Subject the test specimen to 9 minutes per axis random excitation at the following input levels:

20 to 260 H_z - linear increase on log-log coordinates from 0.003 g^2/H_z to 0.039 g^2/H_z
260 to 1000 H_z - constant at 0.039 g^2/H_z
1000 to 2000 H_z - linear decrease on log-log coordinates from 0.039 g^2/H_z to 0.015 g^2/H_z

3.4.7 Acoustics. - The valve shall withstand the random noise environment given in Figure 1. The test specimen shall be mounted in a manner such that it is suspended (isolated from any type of reverberation chamber vibratory excitation) or otherwise completely immersed in a broad-band randomly diffused sound field.

3.4.8 Acceleration. - The valve shall operate within specifications when exposed to the following accelerations:

(a) During boost flight when valve is pressurized but not operating:
Acceleration in longitudinal direction, 7.5. g's
Acceleration in lateral direction, 7.5 g's

(b) When valve is pressurized and operating:
Acceleration in longitudinal direction, 20 g's for 120 sec
Acceleration in lateral direction, 20 g's for 120 sec

(c) When valve is pressurized and not operating:
Acceleration in longitudinal direction, 20 g's for 8 minutes
Acceleration in lateral direction, 20 g's for 8 minutes

3.4.9 Landing Shock. - Not applicable.

One-Third Octave Band Acoustical Specification in DB re 0.0002 dynes/cm^3. Test Duration: 3 minutes

One-Third Octave Band Geometric Mean Freq. (cps)	EXTERNAL SOUND PRESSURE LEVELS High Level (DB)	Low Level (DB) Not Applicable
5.0	130.5	
6.3	132.0	
8.0	133.5	
10.0	135.0	
12.5	136.5	
16.0	137.5	
20.0	139.0	
25.0	140.0	
31.5	141.0	
40.0	142.0	
50.0	142.5	
63.0	143.0	
80.0	143.5	
100.0	144.5	
125.0	145.0	
160.0	145.5	
200.0	146.5	
250.0	147.0	
315.0	147.5	
400.0	148.0	
500.0	149.0	
630.0	149.5	
800.0	150.0	
1000.0	150.0	
1250.0	150.0	
1600.0	150.0	
2000.0	150.0	
2500.0	150.0	
3150.0	149.5	
4000.0	149.0	
5000.0	148.5	
3600.0	148.0	
8000.0	147.5	
10000.0	147.0	
Overall Sound Pressure Level	162.0	

FIGURE 1. Acoustic Environment

3.4.10 Shock. The valve shall be designed to withstand a shock loading of 20 g's peak induced through its normal supports, in any direction. Three shocks of 20 g's peak magnitude (half sine wave with ten (10) milliseconds duration) shall be applied in both directions along the three major axes (total of 18 shocks.) After completion of the shock test, the valve shall meet the response and leakage requirements of paragraphs 3.6.1 and 3.5, respectively.

3.4.11 Radiation. The valve shall be designed to function as required by the specification during and after exposure to radiation as might be experienced in the Van Allen Belts. (10^{-6} rads) When possible, materials of lesser radiation sensitivity shall be used.

3.5 Allowable Leakage. There shall be no allowable liquid propellant leakage. However, during test the allowable gaseous leakage rates shall be as specified below.

3.5.1 Internal Leakage. The maximum leakage **at valve acceptance test across each of the valve seats shall be five (5) standard cc per hour of nitrogen at 50 to 325 psia inlet pressure. During use subsequent to acceptance test the maximum leakage across each of the valve seats shall be two hundred (200) standard cc per hour of nitrogen at 50 to 325 psia inlet pressure.**

3.5.2 External Leakage. **The maximum external leakage shall be 10^{-4} standard cc per second of helium at 325 inlet pressure.**

3.5.3 Reverse Seat Leakage. The maximum reverse seat leakage, when 20 psig nitrogen is applied at the outlet port with the inlet port at atmospheric pressure, shall not exceed 3 standard cc of nitrogen per six minutes.

3.6 Mode of Operation. Each valve shall be electrically actuated through a separate electrical circuit. The coils shall be electrically and physically separated. Each series-leg flow path shall meet its respective response requirements when the valve is actuated with normal working pressure (3.3.3.1) and normal voltage (3.9.1).

3.6.1 Response. - Opening response is the elapsed time between the initiation of the signal to the full open position of the flappers. Closing response is the elapsed time between cessation of the signal to the full closed position of the flappers. The valve assembly shall be capable of cycling at 10 cps.

3.6.1.1 Opening. - Opening response of each series leg shall not exceed fourteen (14) milliseconds when pressurized to the maximum rated pressure (3.3.3.2.1) and utilizing the minimum normal voltage (3.9.1) over the temperature range (3.9.1) and the hot ampere value (3.9.4.3).

3.6.1.2 Closing. - The valve assembly shall close in ten (10) milliseconds maximum.

3.6.1.3 Simultaneity. - The fuel valve assembly and the oxidizer valve assembly shall actuate within 5 milliseconds of each other.

3.6.2 Service Life. - A cycle is defined as an operation of the valve in two directions: an open pulse and a close pulse.

3.6.2.1 Open Pulse. - Pulse width shall vary from 80 milliseconds to 600 seconds.

3.6.2.2 Close Pulse. - Pulse width shall vary from 20 milliseconds to 120 minutes.

3.6.2.3 Operational Cycles. - The valve service life shall exceed 500 dry operational cycles and 50,000 operational cycles while subjected to rated flow and pressure without degradation of performance below the requirements of this specification.

3.7 Weight. - The valve weight shall not exceed 8.6 pounds.

3.8 Reliability. - The minimum required reliability for the solenoid valve is 0.996 at the lower single sided confidence limit of 50 percent. The reliability design goal for the valve shall be 0.99968. The reliability pertains to the probability of successfully meeting the performance requirements under the environmental conditions of this specification for a minimum of 50,000 cycles of operation after delivery to RMD.

A formal reliability test program is not required. However, it is the intent that reliability shall be monitored using the results of all development, acceptance and qualification testing through the procedures of Paragraphs 3.8.1 through 3.8.7. This reliability information will be assessed to determine that the failure modes and failure rates are consistent with the reliability requirements of this specification and whenever the reliability assessment shows that the unit does not meet the requirements, corrective action which is approved by the purchaser shall be taken by the vendor to either eliminate the mode of failure or reduce the failure rate to an acceptable limit.

3.8.1 Design Analysis. - The vendor shall prepare a design analysis report to be used in the Design Reviews conducted by TCC-RMD. The report shall consist of the calculations used to prepare the valve design, effects of tolerance accumulation and a material selection analysis.

3.8.2 Failure Mode and Effect Analysis (FMEA). - The reliability of the valve will be predicated by means of a Failure Mode and Effect Analysis in conformance with NASA Drawing No. 10M30111 Revision A (MSFC) - Procedure for Performing System Analyses. Its purpose is to define critical reliability areas during the development phase and result in recommending appropriate design modification.

A Failure Mode and Effect Analysis (FMEA) will be submitted as required by contract schedule which will be conducted down to the subcomponent and parts level. Identification of the component and parts items of the FMEA will be by item name and drawing number.

The FMEA will be updated to reflect design changes and numerical assessments adjusted to reflect actual experience on the valve.

The FMEA will be used for the following:

(a) The determination of critical reliability areas for design emphasis

(b) The determination of off-limits and malfunction test conditions

(c) Guidance in design and design reviews

(d) An element in the construction by RMD of a reliability math model for the complete engine.

3.8.3 Success Criteria. - A test will be declared a success if the valve meets the performance, response, and reliability requirements of this specification. In addition, the valve must experience no "mechanical" failures (i.e., leaks, ruptures, breaks, etc.).

3.8.4 Failure Criteria. - The following failure criteria apply to all acceptance, development and qualification tests.

(a) Failure to satisfy performance, response, and reliability requirements of this specification.

(b) Any mechanical failure, such as a leak, rupture or break.

3.8.5 Failure and Failure Analysis Reports. - The vendor is required to have a Failure and Failure Analysis reporting system satisfactory to Thiokol-RMD Reliability Group.

3.8.5.1 Failure Report.

A failure report shall be initiated for each failure that occurs after submitting the valve to the Acceptance Tests.
A failure is defined as any deviation from this specification or from the source control drawing. The internal use and distribution shall be at the discretion of the vendor; however, the following rules shall apply.

(a) A positive control shall be used to assure complete reporting.

(b) One copy shall remain with the unit until its eventual disposition by scrap or return to a serviceable condition.

(c) Three (3) copies shall be sent, within five working days after a failure is discovered, to the Thiokol-RMD Purchasing Department for distribution to the:

Engineering Group
Quality Control Group
Reliability Group

(d) The failure report shall contain as a minimum:

1. Date
2. Vendor part number
3. RMD part number
4. Unit Serial Number
5. Failure report number
6. Failure Analysis report number
7. Time and Cycles accumulated to failure
8. Description of the failure
9. Conditions under which failure occurred

3.8.5.2 Failure Analysis Report.
A failure analysis shall be conducted if required by TCC-RMD to establish the mode of failure, cause of failure and planned corrective action. TCC-RMD shall review each Failure Report and within 5 days of receipt inform the vendor if a Failure Analysis Report is required. The following rules shall apply.

(a) A positive control shall be established to ascertain that each failure is analyzed.

(b) The investigation of each failure shall be performed by specialists experienced in failure analysis and acquainted with the materials, processes, and techniques used in manufacture.

(c) All steps taken to determine the cause of failure shall be documented thoroughly, using photographs or sketches with specific measurements where applicable and parts dissected to whatever degree necessary to establish ultimate failure cause.

(d) Within fifteen (15) days after occurrence of a failure, three (3) copies of the failure analysis should be sent to the Thiokol-RMD Purchasing Department for distribution to the:

Engineering Group
Quality Control Group
Reliability Group

(e) The failure analysis report shall contain as a minimum, the items required for the failure report plus the following:

1. The tests run to verify and discover the cause of failure.

2. The cause of failure.

3. Recommended corrective action to prevent recurrence of the failure.

3.8.6 Time and Cycle Log. - A Time and Cycle Log that is satisfactory to RMD Reliability Group is required on each valve. The Log shall contain as a minimum:

(a) Date
(b) Vendor part number
(c) Unit serial number
(d) RMD part number
(e) Number of cycles accumulated
(f) Energized time accumulated (estimated)
(g) Number of dielectric tests accumulated
(h) Failure report and failure analysis number, if applicable.

The time and cycle count shall start with the first submission of the unit to test, accumulate wet and dry cycles separately. All subsequent energized time and cycle, accumulated in rework and/or retest, shall be recorded in the time and cycle log. Upon shipment of the solenoid valve, three (3) copies of the Time and Cycle Log shall be sent to Thiokol-RMD Purchasing Department for transmittal to the:

RMD Reliability Group (2)
Quality Control Group

3.8.7 Refurbishing Valves. - If valves are returned to the vendor for rework or refurbishing, upon completion of repair or other final disposition, such as "scrap" or "return as-is", three (3) copies of the record of the rework or retest performed shall be furnished to the RMD Purchasing Department for distribution to the:

Engineering Group
Quality Control Group
Reliability Group

3.9 Electrical Requirements

3.9.1 Normal Voltage. - Each coil shall be capable of actuating its valve at the response requirements of paragraph 3.6.1 when supplied with a normal terminal voltage supply of 22 to 30 volts D.C. over an ambient temperature range of +12F to 180F and the rated pressure range of 3.3.3.2.1. The nominal voltage shall be 26 volts D.C.

3.9.2 Emergency Voltage. - Each coil shall be capable of reliable valve operation when supplied with an emergency terminal voltage supply of 20 to 33 volts D.C. over an ambient temperature range of +12F to 180F when pressurized to a maximum pressure of 325 psia.

3.9.3 Drop-Out Requirements. - Each coil shall drop out and cause closing of the valve before the voltage decays to 1.0 volt D.C.

3.9.4 Current

3.9.4.1 Cold Amps - Each Coil - 1.3 amperes maximum at 26 vdc and +12F.

3.9.4.2 Cold Amps - Entire Valve - 10.4 amperes maximum at 26 vdc and +12F.

3.9.4.3 Hot Amps. - This value shall be determined by applying 26 vdc across all coils for 450 seconds with the valve dry and insulated. Reduce the voltage to 22 vdc and measure the current to each coil. This value of current shall be used in all acceptance response tests. A calculated value of .580 may be used prior to determination of this test value.

3.10 Flushing Fluids. - All valve materials exposed to propellant shall be compatible with the following propellant neutralizers and decontaminates:

(a) Triethanolamine
(b) Hydroxyacetic Acid
(c) Methyl and Isopropyl Alcohol
(d) Deionized Water
(e) Freon MF
(f) Hot GN_2 at 160F.

3.10.1 Other Fluids. - All materials that will be in contact with the N_2O_4 shall be compatible with Nitric Acid.

3.11 Identification and Marking. - Components shall be identified by the number of the applicable purchaser drawing, which is also the purchaser's part number. This number shall be permanently and legibly marked on the component. The component shall also be identified with the following information which shall be submitted with the component.

(a) Contract number
(b) Purchaser's part number
(c) Vendor's part number
(d) Vendor's name or trademark
(e) Acceptance Test Data
(f) Purchaser's serial number

Ports shall be identified as to direction of flow per Paragraph 3.2.8.1. Markings shall be as specified in RMD Specification 7145, except that if ink (Method II) is used, markings shall be covered with clear, moisture-resistant lacquer or varnish.

3.12 Workmanship. The workmanship and finish shall be of sufficiently high grade to ensure satisfactory operation, reliability, and durability consistent with the service life and application of the valve.

3.13 General Requirements

3.13.1 Drawing Approval. Prior to delivery of initial units, drawings shall be submitted to the purchaser for approval. These drawings shall be assembly drawings prepared in accordance with and to conform to the requirements of MIL-D-70327. The required drawings must be of a quality suitable for producing Type 1, Class 1 first generation microfilm as specified in MIL-M-9868 and shall indicate all materials of construction, the relative position of each part and the identification (including change letter) of each part. The vendor shall furnish six (6) copies of each drawing and the purchaser will indicate approval on the face of each drawing. Two copies of each approved drawing will be returned to the vendor through the purchaser's purchasing department, and as a record of this approval. When parts are reordered, drawings need not be resubmitted for approval unless changes have been made.

3.13.2 Design Changes. The purchaser will prepare a specification control drawing (SCD) from the information supplied by the vendor's assembly drawings. The SCD shall be used to procure parts for qualification and all subsequent use. The vendor shall request changes to SCD as required: incorporation of these changes shall constitute purchaser approval. No Class I design changes shall be made without prior RMD approval in writing. Vendor requests for Class I changes shall be processed in accordance with ANA Bulletin 445. Class II changes (changes which do not apply to details used in the valve assembly or clerical drawing changes) may be made by the vendor as needed. Detail parts of each assembly shall be inspected to determine conformance with the SCD, particularly with regard to part number and change letter and no deviation will be accepted unless incorporated on the SCD.

3.13.3 Design Review. The vendor shall furnish three (3) complete sets of detail and assembly drawings for use in preparation of a component design review by the purchaser.

3.13.4 Status Report. A status report as specified by contract shall include at least the following:

(a) Development program status.

(b) Significant progress and problem areas encountered.

(c) Summary of each failure and corrective action taken.

(d) Reliability status of the valve.

(e) Resume of work to be accomplished during the succeeding report period.

(f) Trend charts for critical parameters.

3.13.5 Certification

3.13.5.1 Radiographic Inspection. Not applicable.

3.13.5.2 Welding. Fusion welds shall be made in accordance with the requirements of MSFC Spec 135. The inspection methods used for Class I welds in which radiographs of 2 percent sensitivity cannot be obtained shall be recommended by the vendor and approved by TCC-RMD and NASA. Penetrant inspection shall conform to MIL-I-6866.

Electron beam welds shall require a simulated sample of joint geometry for each lot of parts to establish welding parameters. This sample shall be submitted to the vendor's Quality Control Group for approval prior to the welding of parts. A copy of this approval shall be maintained by the vendor and shall be made available to the purchaser upon request.

3.13.5.3 Soldering. All operators performing soldering shall be certified per NPC-200-4.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Quality Assurance Program. - The requirements for formal verification of the performance, design, and construction of the quad valve shall be based on the satisfactory completion of the tests listed in this specification. Approval of these test results shall determine the acceptance of the design, the development engineering and qualification of the valves offered for delivery under the terms and conditions of the contract. During the conduct of these tests, the vendor will maintain a quality assurance program conforming with the requirements of this specification and Thiokol-RMD 403-1 Quality Control Requirements for Suppliers.

4.2 Classification of Tests. - Tests to be performed in verification of the valve design and the suitability of valves for delivery shall be classified as follows:

(a) Acceptance Tests. - These tests are conducted on all valves submitted for delivery under the contract. Acceptance tests are conducted to determine conformance of each valve with specification design and performance requirements.

(b) Development Tests. - These tests are conducted to demonstrate that the design integrity and basic functional parameters of the valve design are compatible with the requirements of this specification. Development shall be considered completed when the requirements of these tests are satisfied.

4.2 Classification of Tests. (Continued)

(c) Qualification Tests. - These tests are conducted to demonstrate the suitability of the valve design for production and for unrestricted operational use in spacecraft and stages. The qualification tests will verify that valve operation complies with or exceeds full compliance with the requirements of this specification.

(d) Production Environmental Tests (PET). - These tests are required when specified by Purchase Order. When required, PET tests shall be considered part of acceptance tests.

4.2.1 Responsibility for Performance of Tests. - Unless otherwise specified, in the applicable purchase order, the vendor shall be responsible for conducting acceptance tests, development tests and qualification tests. The purchaser, or his agent, shall be given an opportunity to witness all tests. The vendor shall submit a test procedure for approval, prior to performance of these tests.

4.2.2 Test Reports. - An acceptance test report shall be submitted with each valve at delivery. Development test reports and qualification test reports shall be submitted within thirty (30) days after completion of the tests.

4.3 Development Tests. - Five (5) quad valves shall be subjected to the development tests shown in Table I. Satisfactory completion of all of the development tests shall constitute interim purchaser approval of valve development.

TABLE I

DEVELOPMENT TESTS - QUAD VALVE

TEST	SAMPLE A *	B	C	D	E
Acceptance Test (4.5)	x	x	x	x	x
Solenoid Temperature Test (4.7.12)	x			x	
Operating Tests (4.7.11)	x	x		x	
Sinusoidal Vibration Tests (4.7.18.1)		x			x
Random Vibration Test (4.7.18.2)		x			x
Electrical Interference Tests (4.7.13)	x				
Shock Test (4.7.20)		x			
Sand and Dust Test (4.7.25)			x		
Salt Spray Test (4.7.26)				x	
Pressure Spike Test (4.7.30)			x		
Development Life Test (4.7.14)				x	x
Reacceptance Test (4.5.2)	x	x	x	x	x
Propellant Compatibility (4.7.16)	x				
Burst Test (4.7.15)			x	x	

* Sample A tested by RMD

4.4 Qualification Tests. Quad valves shall be subjected to the qualification tests shown in Table II. The valve shall be considered qualified to this specification when all valves pass the tests indicated. If, during the Qualification test, a part fails, this part may be replaced, or a new Qualification test started on a new valve, providing that the corrective action and retest procedure has been approved by TCC-RMD and NASA.

4.5 Acceptance Tests. Acceptance of each quad valve for delivery shall be predicated on the satisfactory completion of the acceptance test specified herein.

4.5.1 Sampling Instructions. Each valve shall be subjected to all the acceptance tests. The pertinent valve acceptance test data which demonstrated the performance and operating characteristics of the valve shall form a basis for acceptance and shall be recorded and retained in accordance with Thiokol-RMD 403.1. In addition, a copy of the pertinent acceptance test data shall accompany each valve delivered to the purchaser.

4.5.2 Tests. The tests performed for acceptance shall be those listed below:

(a)Examination of Product	(4.7.1)
(b)Proof Pressure Test	(4.7.2)
(c)Electrical Resistance Test	(4.7.3)
(d)Dielectric Strength Test	(4.7.4)
(e)Response Test	(4.7.5)
(f)Flow Test	(4.7.6)
(g)Functional Test	(4.7.7)
(h)External Leakage Test	(4.7.9)
(i)Internal Leakage Test	(4.7.10)
(j)Reverse Leakage Test	(4.7.10.1)

4.5.3 Production Environmental Tests
The following test shall be performed prior to acceptance testing: The dry and unpressurized valve while assembled as part of the TCC-RMD P/N 318000-200 Rocket Engine, Spacecraft (RES) shall be vibrated in the thrust axis only for a two (2) minute duration at the following random vibration spectrum input at the RES mounting surface:

20to 100Hz - constant at .137g^2/Hz
100 to 200Hz decrease at 6.0 db/octave
200 to 700Hz- constant at .034 g^2/Hz
700 to 2000Hz-decrease at 6.0 db/octave

4.6 Test Conditions

4.6.1 General. The apparatus used in conducting tests shall be capable of meeting the conditions required.

4.6.2 Volume. The test facilites shall be such that the part or component under test shall not exceed fifty (50) percent of the internal volume of the test chamber.

TABLE II

QUALIFICATION TESTS - QUAD VALVE

TEST	
Acceptance Tests (4.5)	Vendor test all samples
Temperature Test (4.7.17)	Vendor test one (1) sample
Non-Operating Vibration Test (4.7.18.1)	Purchaser RES Qual Data
Operating Vibration Test (4.7.18.2)	Purchaser RES Qual Data
Acceleration Test (4.7.19)	Purchaser test one (1) sample
Shock Test (4.7.20)	Purchaser RES Qual Data
Handling Shock Test (4.7.21)	Vendor test one (1) sample
Life Test (4.7.22)	Vendor test two (2) samples
Fuel Compatibility Test (4.7.24.1)	Purchaser test one (1) sample
Oxidizer Compatibility Test (4.7.24.2)	Purchaser test one (1) sample
Vacuum Test (4.7.23)	Vendor test one (1) sample
Electro Interference Test (4.7.13)	Purchaser test one (1) sample
Inspection (4.7.1)	Vendor test four (4) samples
Burst Test (4.7.15)	Vendor test one (1) sample

4.6.3 Measurements. - All measurements shall be made with instruments whose accuracy has been verified. If tests are conducted by the vendor, the accuracy of the instruments and test equipment shall be verified periodically by the vendor to the satisfaction of the purchaser.

4.6.4 Tolerances. - The maximum allowable tolerances on test condition measurements shall be as follows:

(a) Temperature. - Plus or minus (±) four (4) degrees Fahrenheit (F)
(b) Altitude. - ± five (5) percent (in feet)
(c) Humidity. - ± five (5) percent relative
(d) Vibration amplitude. - ± five (5) percent (This tolerance is applicable only to the amplitude measuring instruments).
(e) Vibration Frequency. - ± two (2) percent. (This tolerance is applicable only to the frequency measuring instruments).
(f) Voltage. - ± one (1) percent
(g) Pressure. - ± 1/2 percent
(h) Flowrate - ± one (1) percent
(i) Time - ± 3 percent

4.6.5 Ambient Temperature and Pressure. - Unless otherwise specified, all tests shall be conducted at the existing atmospheric temperature and pressure.

4.6.6 Test fluid. - The test fluid shall be dry nitrogen gas, deionized water or as otherwise specified.

4.7 Test Methods

4.7.1 Examination of Product. - **The conformance of each valve with respect to material, workmanship, finish, marking, weight and dimensions in accordance with the applicable drawings shall be certified by the vendor.**

4.7.2 Proof Pressure Test

4.7.2.1 Valve Assembly Test. - Using deionized water, apply proof pressure (3.3.3.3) to inlet port of each valve assembly with all valves open. Maintain this pressure for two (2) minutes. Any evidence of permanent set, distortion, or failure of any kind shall be cause for rejection.

4.7.2.2 Seat Assembly Test - Open the downstream valves and using deionized water, apply valve seat proof pressure (3.3.3.3) to the inlet ports of the valve with the outlet port open and the upstream valves closed. Maintain this pressure for two (2) minutes. Examine for liquid leakage; however, liquid leakage shall not be cause for rejection. Subsequent gas leak check shall be the acceptance criteria. Repeat this test with the downstream valves closed and the upstream valves open.

4.7.3 Electrical Resistance

4.7.3.1 Coil Resistance - Determine the electrical resistance of each coil with the armature in its normal position. **The coil resistance shall be 23 ± 1.2 ohms, at a temperature of 77°F.**

4.7.3.2 Insulation Resistance - Check the insulation resistance of each coil. The resistance shall meet the requirements of 3.2.3.10.2.

4.7.4 Dielectric Strength Test - The test shall be performed at room ambient conditions once during the initial acceptance test only. NOTE: This test shall be deleted for any re-acceptance tests that may be run the valve, provided the valve has successfully passed this requirement during a prior acceptance test. Electrical power shall be applied for ten (10) minutes (28 volts D.C.). While the valve is hot as a result of testing, it shall be subjected to a 1000 VAC RMS at 60 cps dielectric strength test between all pins to valve body and between all pins and the electrical connector body. Any "arc-over" or current in excess of 50 microamperes through any individual pin or noticeable decrease of insulation resistance during or as a result of this test shall constitute a failure.

4.7.5 Response Time Test - This test shall be performed at ambient conditions and using hot amperes determined under conditions specified in Paragraph 3.9.4.3; the electrical schematic for this test is shown in Figure 2. Using de-ionized water, apply 212 psig pressure to both inlet ports of the valve. Restrict the outlet ports to produce the Equivalent Water Flow of (3.3.1). Actuate all coils and determine the time for initial current flow to full travel of poppet as determined by the individual current traces. Then de-energize all coils and determine the response time to close by the individual voltage traces. The time in either case shall not exceed that specified in Paragraph 3.6.1. The response time test shall be performed with all coils in operation.

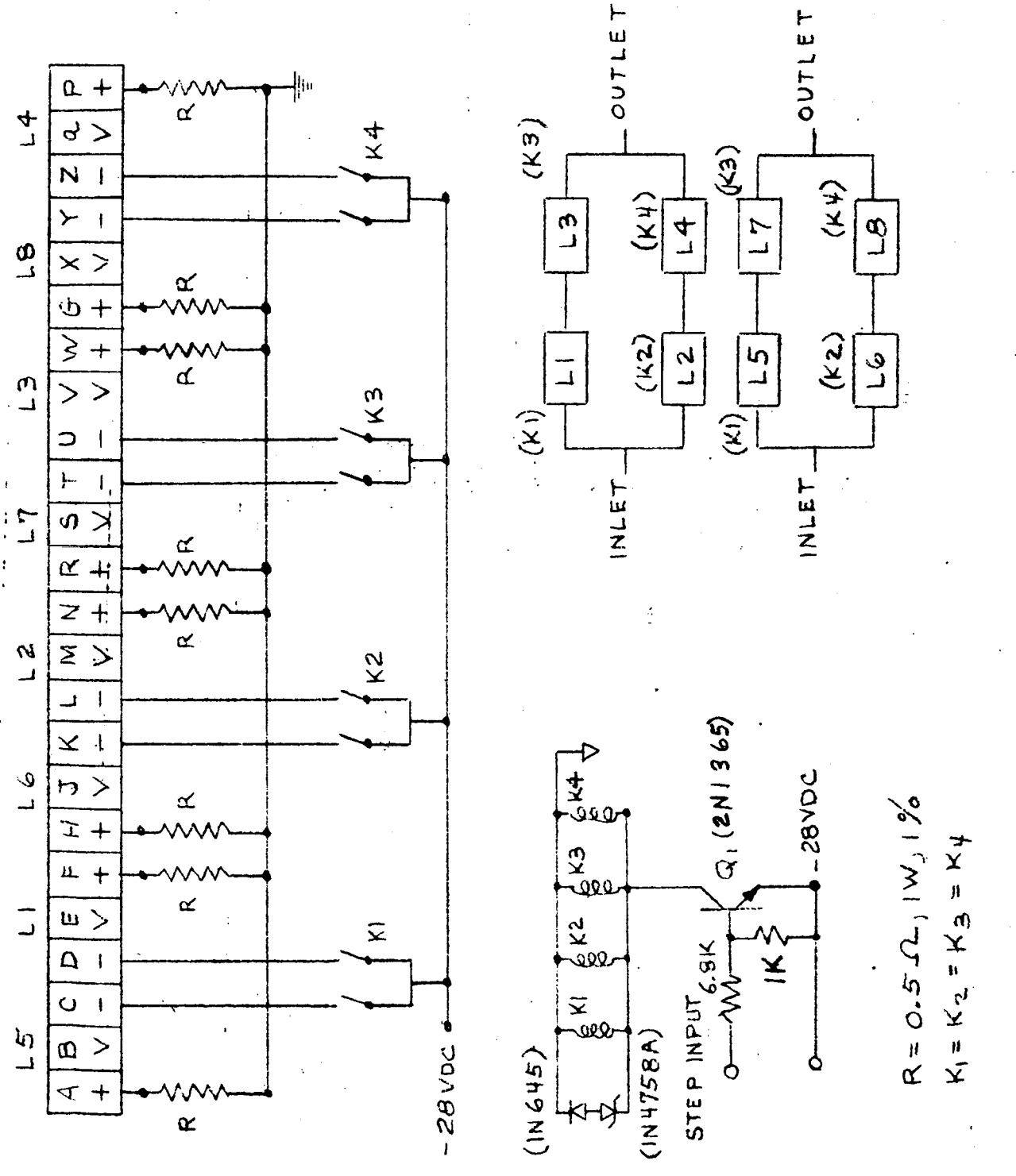


Figure 2. Response Test Schematic

4.7.6 Flow Test - A flow reading shall be taken with the valve energized. Using deionized water, measure the releationship between pressure drop and flow rate for each set of four (4) valves. The flow characteristics of the valve shall meet the requirements of Paragraph 3.3.1 (Flowrate and ΔP based on 80F). Repeat the above test using one flow reading except only open two valves in series at a time.

4.7.7 Functional - Open the four downstream valves using 20 vdc; hold these valves open using 5 vdc. Using deionized water apply 325 psig to the valve inlet ports with the outlet ports restricted to produce the flow characteristics of Paragraph 3.3.1. Apply increasing voltage to the upstream valves individually. Record the minimum voltage required to operate each upstream valve individually for three consecutive cycles. The recorded minimum voltage shall not exceed the minimum emergency voltage (3.9.2). There shall be no malfunction of any valve. Repeat this test on the downstream vlaves with the upstream valves open.

Open all valves using the nominal voltage (3.9.1) and using deionized water apply 166 psig to the valve inlet ports with the outlet ports restricted to produce the flow characteristics of Paragraph 3.3.1. Reduce the voltage to each valve individually with all other valves held open using the nominal voltage (3.9.1) until it drops out as indicated by a flow change. The voltage at which this occurs is drop-out voltage and shall not be less than specified in para 3.9.3 for the downstream fuel valves and the upstream oxidizer valves. The upstream fuel valves and the downstream oxidizer valves shall not drop out. Cycle the valve assembly to insure that a minimum of 2000 cycles will be accumulated on each torque motor. Open the four downstream valves using 20 vdc; hold these valves open using 5 vdc. Apply 5 psig filtered Nitrogen gas to the valve inlet ports. Energize each upstream valve to the open position individually. Then reduce the applied voltage to each upstream valve until it drops out as indicated by a cessation of flow for three consecutive cycles. The drop-out voltage shall not be less than specified in para. 3.9.3. Repeat this test on the downstream valves with the upstream valves open.

4.7.8 Drying Out - After the water tests the valves shall be dried by vacuum drying at a pressure less than the vapor pressure at th[redacted] valve temperature for four (4) [redacted] hours.

4.7.9 External Leakage - Actuate all valves and using helium gas, separately apply the maximum working pressure of paragraph 3.3.3.2 to each inlet port with its outlet port plugged. Determine the external leakage of the entire assembly. Any external leakage (3.5.2) greater than that specified shall be cause for rejection.

4.7.10 Internal Leakage - Open the downstream valves, apply 50 and 325 psig nitrogen to the inlet ports of the assembly. Measure internal leakage. Subject the upstream valves to 100 operational cycles. Then repeat the leakage test. Any internal leakage (3.5.1) greater than that specified shall be cause for rejection.

Close the downstream valves, open the upstream valves and repeat this test except operate the downstream valves 100 operational cycles.

4.7.10.1 Reverse Leakage - Open the downstream valves and apply 20 psig nitrogen to the outlet ports. Measure reverse seat leakage at the inlet ports. Close the downstream valves, open the upstream valves and again apply 20 psig to the outlet ports. Measure reverse seat leakage at the inlet ports. Any reverse seat leakage (3.5.3) greater than that specified shall be cause for rejection.

4.7.11 Operating Tests. - These tests are to demonstrate the physical characteristics of the valves tested. A matrix showing the test conditions and sequence is shown in Table III. The tests may be performed continuously at any one temperature, although the order of testing at a temperature must be random. Pressures shown in Table III correspond to the maximum and minimum working pressures. Voltages are the maximum and minimum normal voltages. Temperatures represent the maximum and minimum ambient and fluid temperatures. During the tests, data shall be recorded for internal leakage, opening response, closing response, maximum coil current, pull-in voltage and drop-out current at temperature extremes. Internal leakage shall be conducted as a separate test on a wetted valve, and a leakage test shall be conducted on dry valves before and after each temperature test. The matrix has been set up to yield a maximum amount of useful data from the valves tested. Upon completion of these tests, the vendor shall analyze the data for variations within a valve, variations among valves, significant differences among valves and upper and lower 3 sigma limits of these variations. The following will be observed during testing:

(a) The test fluid during leakage testing will be N_2 gas. The test fluid for all other testing will be a liquid.

(b) The valve will be exposed to a minimum two-hour soak period prior to testing at any temperature. The soak period begins when the valve external temperature reaches the required level.

(c) Valve current and voltage will be recorded on oscillograph photo to determine opening and closing response, respectively, and steady state current. The response of each series leg of fluid path shall be measured.

(d) Differential pressure will be set at 195 psig inlet and rated flow.

(e) Immediately prior to each test at the 180F valve temperature, the valve will be actuated for a 500 second period using 26 vdc.

(f) All gage connections will be valved off prior to performing a response test.

4.7.12 Solenoid Temperature Test - This test shall be performed with a dry, unpressurized valve suitably insulated to minimize heat transfer from the valve at locally existing atmosperic conditions. Apply nominal voltage (3.9.1) to all coils. Monitor current and voltage to each coil. After a 450 second period, reduce the voltage to the minimum normal voltage (3.9.1) and measure and record current. This value of current is the "Hot Amp" value of paragraph 3.9.4.3. Calculate coil resistance and temperature from the values of current and voltage recorded during the 450 second energizing period.

The calculated final temperature and temperature rise shall meet the requirement of paragraph 3.2.1.3.1.

4.7.13 Electrical Interference Tests - Subject the valve to the tests specified in MIL-I-6181D Paragraphs 4.3.2; 4.3.4; 4.3.4.1; 4.3.4.1.1; 4.3.4.2 and 4.3.4.3 (but not 4.3.4.1.2) only. During testing valve performance shall be continuously monitored for evidence of degradation. Following the test, the valve shall meet response, pull-in and drop-out voltage and leakage requirements.

		T(-) +12F			T(+) +180F		
		Valve Number					
		1	2	3	1	2	3
P(-) 175 psia	E(+) 30 vdc						
	E(-) 22 vdc						
P(+) 325 psia	E(+) 30 vdc						
	E(-) 22 vdc						

Table III. Test Matrix - Quad Valve Operating Tests

4.7.14 Two (2) valves will be subjected to life cycle tests with water, using gas leakage checks and water response checks to evaluate the valve performance. The life cycle test shall continue for 500,000 cycles or failure, whichever occurs first. All coils will be utilized throughout this test. The following tests will be performed to evaluate valve performance at the intervals indicated.

Cycles Completed	Test Per Paragraph
10,000	4.7.5, 4.7.7, 4.7.10, 4.7.10.1
30,000	4.7.5, 4.7.7, 4.7.10, 4.7.10.1
50,000	4.7.5, 4.7.7, 4.7.10, 4.7.10.1
100,000	4.7.5, 4.7.10, 4.7.10.1
200,000	4.7.5, 4.7.10, 4.7.10.1
500,000	4.7.5, 4.7.10, 4.7.10.1

4.7.15 Burst Pressure Test. - Using de-ionized water, bleed all air from the valve and apply burst pressure (3.3.3.4) to the outlet ports of the valve with the inlet ports capped. Maintain this pressure for two (2) minutes. The valve may permanently distort, but no leakage or pressure failure of any kind is allowed. After holding the pressure, slowly increase the water pressure until there is a failure.

4.7.16 Propellant Compatibility.- These tests shall be conducted by the purchaser and the results shall be sent to the vendor for Engineering evaluation. Internal exposure shall be conducted with the valve installed in a closed propellant system at room ambient temperature and with one propellant (3.3.2) at a time. Open the fuel valves and vacuum fill their passages. Close these valves and pressurize the fuel inlet port with normal working pressure (3.3.3.1) for one (1) day. Vent the pressure, drain the valve and then vacuum dry the passages. Repeat this test on the oxidizer passages. At the completion of these tests, conduct response time (4.7.5) and internal leakage (4.7.10) tests. Repeat the above internal exposure procedure except raise the valve ambient temperature to 180°F and keep each inlet port pressurized four (4) days. At the completion ofthese tests, repeat the response time and internal leakage tests. External exposure shall be conducted in accordance with the requirements and procedures in Paragraph 4.7.24.

4.7.17 Temperature Tests Install the valve in a test system. Stabilize the valve, fluid and ambient temperatures at +180F. The valve shall be insulated to minimize heat transfer from the valve. The valve, while pressurized to 212 psig, shall be energized continuously for 500 seconds using nominal voltage (3.9.1). Immediately following the energization period, the valve shall meet response requirements (3.6.1) and minimum emergency actuation voltage (3.9.2) while pressurized to an inlet pressure of 325 psig. The dry valve shall meet leakage requirements (3.5.1) while stabilized at +180F before and after the above test. The above test, less the energization period, shall be repeated with the valve fluid and ambient temperature stabilized at 12F.

4.7.18 Vibration Tests. The valve shall meet the requirements of the indicated paragraphs during Development and Qualification testing as applicable.

	Development Test Table I	Qualification Test Table II
Between Axes After Completion of Vibration	3.5.1 4.5	3.5.1 & 3.6.1 4.5

4.7.18.1 Non-Operating Vibration Test. Subject the valve to the vibration spectrums of paragraph 3.4.6.1.

4.7.18.2 Operating Vibration Test. - Subject the valve to the vibration spectrums of paragraph 3.4.6.2.

4.7.19 Acceleration Test. - Attach the valve to an acceleration test device by a rigid fixture equivalent to a thrust chamber with its longitudinal axis parallel to the direction of acceleration.

4.7.19(cont'd)
Using deionized water, pressurize the valve with minimum working pressure (3.3.3.2) for the duration of the test. Subject the valve to the acceleration requirements of paragraph 3.4.8, parts (b) and (c). While operating the valve for part (b), conduct at least two response tests (4.7.5) for each coil and for all coils in operation. Immediately after completion of acceleration tests, conduct a leakage test in accordance with the requirements of paragraphs 4.7.9. and 4.7.10. The valve shall be remounted to the test device in each lateral axis and the test repeated.

4.7.20 Shock Test Expose the valve to the shock loading specified in Paragraph 3.4.10. The valve inlet ports shall be pressurized to the minimum working pressure (3.3.3.2) during this test. At the completion of shock testing conduct a response test (4.7.5) and leakage test (4.7.9, 4.7.10, and 4.7.10.1).

The shock test shall be repeated on each major axis for a total of eighteen (18) shocks.

4.7.21 Handling Shock Test. The valve shall be placed on a solid hardwood bench top. Using one edge of the valve as a pivot, tilt it up so that the opposite edge is at a 45 degree angle to the table, and permit the valve to drop freely. Repeat, using each edge of this face for a total of four drops. Then lift the entire valve one (1) inch above the bench and allow it to drop freely and parallel. Repeat the above with the valve resting on other faces until it has been dropped five (5) times on each face. At the completion of this test, the valve shall meet the response and leakage test requirements of Paragraphs 4.7.5, 4.7.9 and 4.7.10.

4.7.22 Life Test Mount the valve to a test fixture which simulates or duplicates the chamber injector assembly, and conduct a leakage test in accordance with the requirements of Paragraphs 4.7.9 and 4.7.10.

Pressurize the valve with maximum water working pressure (3.3.3.2) and cycle the valve at the rate of 10 operational cycles per second for a total of 10,000 cycles. Conduct a response test in accordance with the requirements of Paragraph 4.7.5; operate the valve dry and unpressurized for 100 cycles and repeat the leakage tests.

4.7.22(cont'd)
This procedure shall be continued and the valve response and leakage performance evaluated at 20,000, 30,000, 40,000 and 50,000 cycles. The external coil cover temperatures shall be monitored and shall not exceed 350F under any mode of operation.

4.7.23 Vacuum Tests. The valve shall be subjected to a simulated altitude pressure no greater than 10^{-6} millimeters of mercury for a minimum period of 346 hours at ambient temperature. Once every five (5) days and once during the last hour of this test, maintaining altitude conditions, each coil of the quad valve shall be energized by increasing the voltage from zero (0) at a slow uniform rate (5-15 volts per minute) until the voltage reaches 30 vdc. The maximum pull-in voltage shall be recorded. The 30 vdc shall be maintained for five (5) minutes and the voltage then decreased, at a slow uniform rate (5-15 volts per minute) until the coil de-energizes. The minimum deactuation voltage shall be recorded. The valve shall be cycled 100 times (Off-On-Off being one cycle) over a range of voltage from 20 to 30 vdc. While the coils are still hot from the cycle test, they shall be subjected to the following tests; once every five (5) days perform an insulation resistance test in accordance with paragraph 3.2.3.10.2. During the last hour of the test the quad valve shall be subjected to a 600 VAC RMS at 60 cps dielectric strength test for one minute between all pins to valve body and between all pins to the electrical connector body. Arc-over or current flow in excess of 50 microamperes shall constitute a failure.

4.7.24 Propellant Compatibility

4.7.24.1 Fuel Compatibility Test. - The valve, mounted in an attitude typical of stage/spacecraft installation, shall be placed in a chamber and subjected to a spray of liquid fuel, directed toward the valve in a straight line, at any angle not greater than 45 degrees from the vertical. The exposure shall be continued until all the exposed surfaces, which the above procedure will wet, have been wetted. The fuel shall be maintained at 160F. The valve shall be air dried for twenty-four (24) hours at 80F and ambient humidity, after which the valve shall be removed from the chamber and inspected for signs of corrosion or incompatibility.

4.7.24.2 Oxidizer Compatibility Test. - The valve, mounted in an attitude typical of stage/spacecraft installation shall be placed in a chamber and subjected to a spray of liquid oxidizer, directed toward the valve in a straight line, at any angle not greater than 45 degrees from the vertical. The exposure shall be continued until all surfaces, which the above procedure will wet, have been wetted. The oxidizer temperature shall be maintained at 65F. The valve shall be air-dried after twenty-four (24) hours at 80F and ambient humidity, after which it shall be inspected for signs of corrosion or incompatibility.

At the conclusion of this test, the valve shall be mounted in a chamber in a typical installation position and exposed to oxidizer vapor. The chamber shall be closed with the internal air at 70F and at least 80 percent relative humidity. Liquid oxidizer shall be introduced into the bottom of the chamber and maintained throughout the test. The oxidizer shall be heated to at least 70F to expose the component to gaseous oxidizer. Humidity shall be controlled by observing a maximum 4F differential between wet and dry bulb readings. After an exposure of 60 ± 1 minutes, and the valve shall be air-dried at 80F and ambient humidity for a period of twenty-four (24) hours, it shall be inspected for signs of corrosion or incompatibility. At the completion of these tests, repeat the response time and external leakage tests of paragraphs 4.7.5 and 4.7.9.

4.7.25 Sand and Dust Test. Subject the valve to the test specified in MIL-STD-810, Method 510, Procedure I. Following the test, the valve shall meet **dielectric strength and insulation resistance requirements.**

4.7.26 Salt Spray Test. Subject the valve to the test specified in MIL-STD-810, Method 509, Procedure I. Following the test, the valve shall meet **dielectric strength and insulation resistance requirements.**

4.7.27 Rain Test. Not Applicable.

4.7.28 Fungus Test. Not applicable.

4.7.29 Maximum Temperature Test. Not applicable.

4.7.30 Pressure Spike Test. Subject the open valve to 100,000 pressure pulses of 1150 psi. The rise and decay time of the pulse shall be approximately 1,000,000 psi/sec.

5.0 PREPARATION AND DELIVERY

5.1 Preservation. No contact preservative shall be applied to any part of the valve and all external threads shall be covered with suitable protectors. The surfaces of these protectors shall be neutral and acid free as defined by Specification JAN-P-121.

5.1 Preservation. - (continued)

Openings to the interior of the valve shall be sealed with metal closures. Openings which cannot be sealed adequately with such a closure shall be adequately masked to exclude dirt and other foreign materials. Protective precautions shall be taken to insure that all internal surfaces are clean and dry at the time of packaging in a heat sealed bag.

5.2 Cleaning. - All valves procured to this specification shall be cleaned by the vendor prior to delivery in accordance with the requirements of the purchaser's applicable specification control drawing. A certification stating conformance with the requirements of this paragraph shall be submitted with all components delivered.

5.3 Packaging. - The valves shall be packaged to withstand commercial transit, so that upon receipt by the purchaser, they shall be capable of meeting the requirements of this specification.

6. NOTES

6.1 Definitions. - For purposes of this specification, the following definitions shall apply.

(a) Vendor. - This term shall be interpreted to mean the manufacturer.

(b) Purchaser. - This term shall be interpreted to mean the vendor's customer.

Thiokol
REACTION MOTORS DIVISION

APPENDIX L

PART I
QUADREDUNDANT VALVE
QUALIFICATION TEST PROCEDURE

MOOG MR 1167

QUALIFICATION TEST PROCEDURE

FOR

QUADREDUNDANT VALVE ASSEMBLY, TORQUE MOTOR OPERATED, PULSE MODULATED, MOOG MODEL NO. 50-304

MOOG INC.
Report No. MR 1167

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Date: January 25, 1967

REFERENCES

1. "Quadredundant Valve Assembly, Detail Specification For", Thiokol Chemical Corporation, Reaction Motors Division Specification EC 20518, includes Revision F, dated 12-15-66

2. Valve, Propellant

   Valve, Propellant Quad Redundant (Specification Control Drawing) Thiokol Chemical Corporation, Reaction Motors Division Drawing 317013 Revision C, dated 9/23/66

3. Thiokol Chemical Corporation, Reaction Motors Division, Denville, N. J. purchase order B86716.

4. "Development Test Procedure for Quadredundant Valve Assembly, Torque Motor Operated, Pulse Modulated, Moog Model 50-304", Moog Report No. MR 1132, Rev. A.

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1.0 INTRODUCTION

1.1 Scope

This document serves as the test directive and the test procedure for Qualification Testing of the Moog Model 50-304 Quadredundant Valve Assembly. Relating to the test directive function, a complete program description is included in this document encompassing test specimen description, program outline, test sequence, test conditions, test facilities and equipment, and the documentation requirements. Also, the detailed procedures to be utilized during the conduct of performance, functional and environmental tests are included.

1.2 General

The purpose of the Qualification Test Program is to demonstrate that the Moog Quadredundant Valve Assembly design can meet the requirements of TCC-RMD Specification EC20518, Revision F, and TCC-RMD Drawing 317013. Qualification Testing of the Model 50-304 Quadredundant Valve is authorized by RMD Purchase Order B85928 and Moog Job Order 1826206.

This test program will consist of performance and environmental testing of three test specimens representative of the production item. These tests will be performed by the Reliability Engineering Group of Moog, Inc., and when possible, using the facilities of the Moog Reliability Engineering Laboratory. Certain environmental tests will require facilities of outside laboratories. However, a Moog Reliability Engineer or Technician will witness all tests and will participate in the conduct of all environmental tests.

2.0 TEST SPECIMEN

2.1 General

The Development Test Program will be performed on three (3) Moog Model 50-304 Quadredundant Valve Assemblies, TCC-RMD Part Number 317013. These valves are manufactured by Moog, Inc., East Aurora, New York, for the Thiokol Chemical Corporation, Reaction Motors Division, Denville, New Jersey.

2.2 Design and Operation

The Quadredundant Valve Assembly is composed of one Moog Model 52-150 oxidizer flow control valve and one Moog Model 52-151 fuel flow control valve. Each valve employs four single air gap torque motors which are designed to open and close flapper type valves in a "bang-bang" fashion. The four torque motor-flapper valves are arranged to provide two parallel metering channels. Each channel is controlled by two series torque motor-flapper valves.

The flapper of each torque motor is supported by a flexure tube which acts as a flexible fluid barrier between the electromagnetic (torque motor) and the fluid (wetted) sections of the valve. A magnetic bias is built into the motor-armature assembly to provide a closing and seal-off force at the flapper nozzle seal with no signal applied to the torque motor coils. When a sufficient signal is applied to the torque motor coils the armature is displaced in the air gap and pivoted about the flexure tube producing a similar movement of the flapper in its respective fluid cavity. The flapper movement away from the nozzle seals provides the orifice through which the propellant flow is metered. The valve pressure drop plus the magnetic bias provide the required closing and seal-off force with no signal applied.

3.0 TEST PROGRAM

3.1 General

Each of the three (3) specimens will be subjected to the test program specified in Table I. This table shows the tests to which a particular specimen will be subjected and specifies the sequence of testing. Whenever possible, specimens having identical test requirements will be tested sequentially to minimize the number of equipment setups and to expedite the Qualification Test Program.

TABLE I

QUALIFICATION TESTS

MODEL 50-304 QUADREDUNDANT VALVE

Test	Ref. Para. EC20518	Test Specimen A	B	C
Initial Performance	4.5	1	1	1
Temperature Test	4.7.17	2	2	
Sinusoidal Vibration Test	4.7.18.1	3	3	
Random Vibration Test	4.7.18.2	4	4	
Acceleration Test	4.7.19	5	5	
Shock Test	4.7.20	6	6	
Handling Shock Test	4.7.21	7	7	
Life Test	4.7.22	8	8	4
*Fuel Compatibility	4.7.24.1	9		
*Oxidizer Compatibility	4.7.2.4.2	9		
Vacuum Test	4.7.23			2
*Electro Interference Test	4.7.13			3
Final Performance	4.5	10	10	5
Burst Test	4.7.15	11	11	

* Tests to be performed by Thiokol Chemical Corporation, Reaction Motors Division.

3.2 Performance Tests

The initial and final performance tests, called out as Acceptance Test in Table I, will essentially duplicate the tests to be performed by Moog, Inc., production department for final acceptance, and are listed below. Interval performance tests listed below preceeded by an asterisk.

1. Examination of Product
2. Proof Pressure Test
*3. Electrical Resistance Test
4. Dielectric Strength Test
*5. Response Test
*6. Flow Test
*7. Functional Test
*8. External Leakage Test
*9. Internal Leakage Test
*10. Reverse Seat Leakage Test

3.3 Environmental Tests

The environmental tests to which the test specimen will be subjected are included in Table I. Satisfactory completion of these tests and approval of the test report by Thiokol Chemical Corporation, Reaction Motors Division shall constitute qualification of the Moog Model 50-304 Quadredundant Valve.

3.4 Status Report

Status reports will be prepared each month covering the status of the Qualification Test Program to date. Each report will cover significant progress and problem areas encountered during the report period. Data obtained from the various tests and photographs of the test setups will also be included. These reports will be submitted to RMD on the 15th day of each month.

3.5 Final Test Report

A final test report documenting the results of all Qualification tests will be prepared and submitted to RMD within 30 days after completion of the test program. This report will contain the results of all acceptance, performance, interval performance, and environmental tests. Test results will be presented in tabulated or plotted form where possible to facilitate data comparison and for recognition of trends. The report will also include a summary of test results with recommendations and conclusions.

4.0 TEST CONDITIONS

4.1 General

Unless otherwise stated in the detailed test procedure, all measurements and tests will be performed at standard conditions. Standard conditions are described as follows:

Ambient Temperature	80± 15° F
Atmospheric Pressure	Locally existing
Test Fluid	Deionized water, dry nitrogen gas, helium trace gas
Supply Pressure	As specified for individual tests.
Fluid Temperature	80 ± 10° F

The maximum allowable tolerances on test condition measurements will be as follows:

Temperature	±4° F
Altitude	±5% (feet)
Humidity	±5% Relative
Vibration Amplitude	±5% This tolerance is applicable to the amplitude measuring instruments
Vibration Frequency	±2% This tolerance is applicable to the frequency measuring instruments
Voltage	±1%
Pressure	±0. 5%
Flow Rate	±1%
Time	±3%

4.2 Fluid Contamination Control

The test facilities to be utilized for testing at Moog Inc. are included under the contamination controls of the Moog Quality Control Department. Test facilities to be utilized at outside laboratories during environmental testing will require fluid sampling prior to initiating testing and on a daily basis if testing continues for more than one day. The contamination limits, determined by the basic methods specified in ARP 598, will be as follows:

Particle Size (Micron)	Maximum Number of Particles Per 100 ML Sample
5-25	40,000
26-50	1,500
51-100	250
100 + (including fibers)	20

The millipore filter disks used for all particle counts will be preserved in labeled containers and will be retained by Moog Inc.

5.0 DOCUMENTATION

5.1 Test Data

The test data recorded during Acceptance, Performance, and Environmental tests will be filed in its original form at Moog Inc, and will be available for inspection by TCC-RMD at any time. The test data will be recorded on appropriate forms for each type of test.

5.2 Status Reports

Program status reports will be prepared each month and submitted to TCC-RMD. Each report will include a description of all significant progress, the problem areas encountered and the test data (raw or reduced) obtained during the report period. These reports will be submitted to TCC-RMD on the 15th of each month.

5.3 Failure and Failure Analysis Reports

In the event of a failure occurrence during any test, notification will be given to TCC-RMD. The failure report will include test specimen identification, test accomplished, test date or dates, test facility, a general statement of the test results, a detailed description including the sequence of events prior to failure, and any other information pertinent to the failure.

Failure analysis will be carried out only after TCC-RMD has been fully acquainted with the failure evidence and the test situation, and has been given an opportunity to participate in the analysis. Test specimen disposition will be by direction of TCC-RMD.

5.4 Final Report

After completion of all qualification tests, a final test report will be prepared and submitted to TCC-RMD. This report will contain the results of all acceptance, performance, interval performance and environmental tests. Test results will be presented in tabulated or plotted form where possible, to facilitate data comparison and recognition of trends. The report will also include a summary of test results with recommendations and conclusions.

If failures have occurred during the test program each discrepant data observation will be noted, and each failure mode will be discussed. Also, all Failure Analysis Reports will be appended.

Approval by TCC-RMD of the final test report shall constitute approval and completion of the qualification test program.

6.0 TEST PROCEDURES

6.1 Performance Tests

6.1.1 Examination of Product

Each valve assembly will be visually examined to determine that it conforms to the applicable drawings with respect to material, workmanship, finish and marking. The dry weight of each valve assembly will be measured and its weight will be recorded on the test data sheet.

6.1.2 Proof Pressure Test

6.1.2.1 Valve Assembly

The valve assembly will be mounted on a deionized water test stand. All torque motors will be energized open with 20 vdc. The returns to the water test system will be closed and supply pressure at 720 psig will be applied to the fuel and oxidizer inlet ports. These conditions will be maintained for two minutes. The valve assembly will be visually monitored for evidence of permanent set, distortion, and external leakage. Observations will be recorded on the test data sheet.

6.1.2.2 Seat Assembly

The valve assembly will be mounted on a deionized water test stand. The downstream ozidizer and fuel torque motors will be energized, and inlet pressure will be adjusted to 720 psig. The valve assembly return ports will be monitored for evidence of external leakage for a two minute period. If leakage occurs, the leakage rate will be determined and recorded on the test data sheet. The test will then be repeated except that the upstream torque motors will be energized and the downstream torque motors will be de-energized.

6.1.3 Electrical Resistance

6.1.3.1 Coil Resistance

The valve assembly will be allowed to stabilize at room temperature prior to this test. The resistance of each torque motor coil will be measured using a Resistance Bridge, Model 638R or equivalent. The measured resistances and the existing room temperature will be recorded on the test data sheet. The resistance for each coil shall be 23 ohms ± 5% when corrected to 77° F.

6.1.3.2 Insulation Resistance

A 500 VDC Megger, Associated Research, Model 224A or equivalent, will be used to measure the insulation resistance between:

a) each set of coil leads and the valve body;

b) each set of coil leads and the other seven sets (Parallel) of coil leads.

The insulation resistance, in megohms, will be recorded on the test data sheet.

The insulation resistance shall be greater than 100 megohms.

6.1.4 Dielectric Strength

A leakage tester, Slaughter Co. Model 103-2.5J or equivalent, will be used to measure the dielectric strength of the valve assembly. A potential of 1000 vac at 60 cps, will be applied for one (1) minute as follows:

a) Between the paralleled coil leads and the valve assembly.

b) Between the paralleled coil leads and the electrical connector shell.

The leakage current, in microamperes, will be measured for each condition and will be recorded on the test data sheet.

Any "arc-over" or current in excess of 50 microamperes or noticeable decrease in insulation resistance during or as a result of this test will require the testing of each coil individually to insure that no one coil exceeds 50 microamperes.

6. 1. 5 Response Time Test

The supply pressure to the valve assembly inlet ports will be adjusted to 195 psig. All torque motors will then be energized open and the return port flows will be set, by adjusting downstream trimming valves, to produce water flow of 0. 144 lb. / sec. on the fuel side and 0. 179 lb. /sec. on the oxidizer side.

The valves will then be de-energized. The opening and closing response times will be determined while operating the torque motors in the following modes:

a) Individual motors with the other motor common to that series leg energized open with a minimum voltage (5-10 volts.)

b) Individual motors while all motors are being operated sinultaneously with hot amps applied.

The response times will be determined while energizing the torque motor coil (s) with "hot amps" at a frequency of 0. 1 cps. The "hot amps" condition is arrived at by adjusting a rheostat which is connected in series with the torque motor coil to produce a current value of 0. 605 amps, with 22 volts across the coil-rheostat circuit.

While the valve is cycling under these conditions, the test torque motor coil voltage and current will be displayed on a dual beam oscilloscope. Opening response time will be determined from the current trace and closing response will be determined from the voltage trace. Photographs of the oscilloscope traces will be made for each torque motor response at condition (b), individual torque motor response times (condition (a)) will be determined directly from a storage oscilloscope trace and the values will be recorded on the test data sheet.

6. 1. 6 Flow Test

The valve assembly will be installed on the water test system. The inlet pressure to each inlet port will be set and maintained at 195 psig. The pressure drop across the valve will be varied in 5 psid increments and the return flow will be measured and recorded at the following test conditions:

a) Both series legs flowing, oxidizer and fuel sides. Pressure drop varied from 5 to 15 psid on the fuel side and from 7 to 17 psid on the oxidizer.

b) One series leg flowing, oxidizer and fuel side. Pressure drop varied from 15 to 35 psid on the fuel side and from 20 to 40 psid on the oxidizer side.

c) Repeat (b), except with the other series legs flowing.

In addition to the above tests, the pressure drop at rated flow will be recorded on the test data sheet for each test condition.

6. 1. 7 Functional Test

6. 1. 7. 1 Pull-In Voltage

The supply pressure to the valve assembly inlet ports will be adjusted to 195 psig and the downstream trimming orifices

will be adjusted to obtain rated flow from the oxidizer and fuel ports. The supply pressure will then be increased to 325 psig and the pull-in voltage: i. e. ; the minimum voltage level at which the valve can be operated (open-close) for three consecutive cycles; will be measured for the following operating modes:

a) Individual torque motor operation with the other motor common to that series leg energized open with a minimum holding voltage (5 to 10 vdc.)

b) Individual torque motor operation while operating in parallel pairs. The torque motor pairs are stipulated in Figure 1. Motors common to the series legs will be energized open with a minimum holding voltage (5-10 vdc).

To determine the pull-in voltage for each operating mode, the coil voltage to the motor(s) being tested will be slowly increased (100-200 volts/min.) from 0 vdc until the valve opens. The signal voltage will then be cycled on-off at 0. 25 cps. and increased as required until ten consecutive cycles of operation are accumulated at a voltage level. The coil voltage and current will be measured and recorded on the test data sheet.

6. 1. 7. 2 Drop-Out Voltage

The supply pressure to the valve assembly inlet ports will be adjusted to 166 psig. The drop-out voltage and current; i. e. ; the maximum voltage and current levels at which the valve closes; will be measured while operating the torque motors in the following modes.

(a) Individual motors with all other motors energized at 26 vdc.

(b) Individual motors while operating in parallel pairs. The motor pairs are defined in Figure 1. Motors common to the series legs will be energized open with a minimum holding voltage (5 to 10 vdc).

(c) Pressurize the valve assembly inlet ports with GN_2 at 5 psi. Determine the drop out voltage for each torque motor with the torque motor common to the series leg energized open with a minimum holding voltage (5-10 vdc).

To determine the drop-out voltage for each operating mode, the input voltage will first be adjusted to 26 vdc. The signal voltage will then be slowly decreased (100-200 volts/min.) until the valve closes. The coil voltage and current at valve closure will be measured and recorded on the test data sheet.

6.1.8 External Leakage

A leak detector, CEC Model 24-120B or equivalent, will be used to measure the external leakage of the valve assembly. The valve assembly will be installed in the helium leakage detection chamber with the oxidizer and fuel outlet ports closed off. The oxidizer inlet port will be pressurized with helium trace gas at 325 psig. The external leakage will be measured and recorded on the test data sheet. The oxidizer inlet pressure will then be reduced to 0 psig and the fuel inlet port will be pressurized with helium trace gas at 325 psig. The external leakage will be measured and recorded on the test data sheet.

Prior to performing any helium leakage tests the C. E. C. leak detector will be calibrated using a C. E. C. Standard Leak (3.17×10^{-8} std cc/sec.) or equivalent. Before calibration is attempted, the leak detector will have been turned on and allowed to warm-up for at least one-half hour. Following the warm-up period the instrument will be adjusted so that the output meter electrical zero and the "no helium leakage" meter reading are coincident. If the readings are not the same the "no helium leakage" meter reading must be used in the leakage calculation shown below. The C. E. C. Standard Leak will then be ported to the leak detector and the output meter reading and meter attenuator scale will

be recorded. The instrument sensitivity will then be calculated from the following formula.

S = instrument sensitivity in standard cc of helium per second.

Q = C. E. C. Standard Leak rate (3.17×10^{-8} std. cc/sec.)

M = Meter output reading with the standard leak attached (Meter Divisions X Attenuator setting)

Z = Meter output reading without the standard leak (Meter Divisions X Attenuator setting)

$$S = \frac{Q}{M - Z} \text{ std. cc/sec/division}$$

The instrument sensitivity is determined using a standard leak of 100% helium gas. The valve assembly external leakage tests are performed using a 10% helium trace gas. Therefore, the meter reading obtained during valve assembly leakage tests must be multiplied by ten (10) when the valve assembly external leakage rate is computed.

6. 1. 9 Internal Leakage

Prior to conducting this test, the unit will be vacuum dried except when conducting the inter-axis performance tests during vibration, acceleration, shock and development life testing. During these tests the unit will be flushed with alcohol and nitrogen gas will be passed through it to remove all water or oil from the unit.

The internal leakage across each flapper-seat assembly will be measured with inlet pressures of 50 psig and 325 psig. When measuring upstream valve seat leakage, the downstream valve will be held open with a minimum voltage (5-10 volts) and the other parallel leg torque motors will not be energized. When measuring downstream valve seat leakage, the upstream valve will be held open.

After leakage measurements have been made for each flapper-seat assembly at the two inlet pressure levels the valve will be cycled on-off ten (10) times. The leakage tests will then be repeated.

Reverse seat leakage will be measured across the individual flapper-seat assemblies with pressure at 20 psig. The pressure will be applied to the return port and the inlet port will be monitored for leakage.

The internal leakage tests will be performed using GN_2 as the pressurizing medium. The water displacement method will be used to measure the leakage. All leakage measurements will be recorded on the test data sheet.

6.2 Environmental Test Procedures

6.2.1 Temperature Test

The valve assembly will be installed in the test system shown schematically in Figure 2.

The first test to be performed with the valve body temperature stabilized at +180° F will be the internal leakage test. This test will be performed prior to wetting the valve with hydraulic fluid. The internal leakage will be measured with the valve pressurized with dry nitrogen gas at 50 psig and at 325 psig.

The trimming valves will be adjusted to provide rated flow, with inlet pressure at 195 psig, from each valve at standard conditions and will not be readjusted during each test sequence.

Prior to iniating tests at +12° F and +180° F a partial performance test will be conducted on the hydraulic test system to obtain correlation data. The tests to be conducted will be the same dynamic tests as those to be conducted at the test temperatures and are as follows:

Opening Response per paragraph 6.1.5, condition (b)
Closing Response per paragraph 6.1.5, condition (c)
Pull-in Voltage per paragraph 6.1.7.1, condition (b)
Drop-out Voltage per paragraph 6.1.7.2, condition (b)

After correlation data has been taken the chamber temperature will be adjusted to the test temperature, either +12° F or +180° F. The valve assembly will be soaked at the test temperature for a minimum of two (2) hours. The two (2) hour soak period will start after the valve assembly temperature has stabilized.

With fluid and ambient temperatures adjusted to and maintained at +180° and with the valve wrapped with insulating material to minimize heat dissipation to the surroundings the following test sequence will be accomplished with the valve pressurized to 325 psig. All coils will be energized at 26 vdc for a 500 second period. The excitation voltage will then be reduced to 22 vdc and the individual coil currents will be measured and recorded. These current values will be used during response testing at 180° F. Inlet fluid pressure will be maintained at 325 psig and the valve will be tested for opening response, closing response, and pull-in voltage. Inlet pressure will then be reduced to 166 psig and the valve will be tested for drop-out voltage and current. The valve will then be returned to standard conditions and an interval performance test will be conducted.

The valve will then be subjected to the temperature test described above except that the test temperature will be +12° F, the coils will not be energized for the 500 second period, and the response tests will be performed without maintaining the "hot amps" or hot coil simulation current values.

6. 2. 2 Sinusoidal Vibration

The valve assembly will be subjected to the sinusoidal vibration test while attached to the Moog Vibration Fixtures (P/N's T-13019, T-13020, and T-13086). During the vibration test in each axis the valve assembly will be filled and pressurized to the upstream values with MIL-H-5606 hydraulic fluid at 151 psig. The vibration input will be controlled as near as possible to the valve mounting surface. The controlled input will be defined by TCC-RMD upon completion of all development vibration testing.

The vibration amplitude at the valve assembly and at the test fixture will be recorded on an oscillograph from the outputs of accelerometers attached to the test specimens in the three orthogonal axes. Also, the filtered outputs of the control accelerometer and the accelerometer in the axis of test on the quadredundant valve will be plotted vs frequency on an X-Y recorder. The X-Y plots will be included as test data in the final report.

During the vibration test in each axis, no liquid leakage is allowed per EC 20518F. To establish that the valve does or does not leak during vibration, the following steps must be adherred to prior to the vibration test in each axis.

1) Disconnect electrical leads to prevent energizing the upstream valves by mistake.

2) Clean the valve assembly-test fixture mounting surface so there is no residual hydraulic fluid on or in the valve assembly or fixture.

3) Mount the valve assembly to the test fixture and make the necessary hydraulic connections.

4) Pressurize the inlet ports with hydraulic fluid at 166 psig. Bleed lines to remove any entrapped air.

5) Conduct one-axis vibration test.

6) Reduce supply pressure to zero psig and remove hydraulic lines.

7) Clean all external surfaces, flush away all traces of hydraulic fluid.

8) Remove the valve assembly and inspect for evidence of hydraulic fluid leakage of the valve outlet ports. Describe the results on the test data sheet.

After the vibration test in each axis is completed, the valve assembly will be subjected to the response test of paragraph 6. 1. 5, condition (b) and the internal leakage test of paragraph 6. 1. 9. At the conclusion of the third axis vibration test, the valve assembly will be subjected to an interval performance test.

6. 2. 3 Random Vibration

The valve assembly will be subjected to random vibration while mounted on the Moog Test Fixture (P/N's T-13019, T-13020, and T-13086). During the vibration test in each axis the valve assembly will be filled and pressurized to the upstream valves with Mil-H-5606 hydraulic fluid at 151 psig. The vibration input will be controlled at the valve mounting surface. The controlled input will be defined by TCC-RMD upon completion of all development vibration testing.

The test specimen will be installed on the vibration fixture and a random vibration input 9 db down from the specification level will be applied. A spectral density analysis of the control accelerometer output will be recorded to insure that the proper equalization has been achieved, within ± 3 db, except that over narrow bandwidths, total not to exceed 500 cps, an additional ± 1. 5 db will be allowed). If the equalization plot is satisfactory, the level will be increased to the test level.

During each axis test the valve assembly will be checked for internal leakage as described in paragraph 6. 2. 2. Also, during test, the outputs of accelerometers attached to the test fixture and valve assembly in the three orthogonal axes will be recorded on magnetic tape. These recordings will be analyzed to determine actual vibration levels at the valve assembly.

After the vibration test in each axis is completed, the valve assembly will be subjected to the response test of paragraph 6. 1. 5, condition (b) and the internal leakage test of paragraph 6. 1. 9. At the conclusion of the third axis vibration test, the valve assembly will be subjected to an interval performance test.

6. 2. 4 Acceleration Test

The valve assembly will be mounted on a test fixture and installed on the arm of a centrifuge. Electrical and hydraulic connections will be provided to permit pressurizing and operating the valve. The valve will then be subjected to the response test of paragraph 6. 1. 5, condition (b), to provide base or reference data for the test setup. The valve will then be removed from the test setup. The test fixture and the valve will be flushed until there are no traces of hydraulic fluid at the fuel and oxidizer outlets. The return lines will be removed from the test fixture.

The valve assembly will then be reinstalled on the test fixture and the valve assembly will be filled and pressurized to the upstream valves with Mil-H-5606 hydraulic fluid at 151 psig. The valve will then be subjected to a sustained acceleration of 20G for 8 minutes. The valve will then be depressurized, removed from the test fixture, and the fuel and oxidizer outlet ports will be inspected for evidence of fluid leakage. The valve will be subjected to 8 minutes of acceleration in each direction along the three mutually perpendicular orthogonal axes. After each 8 minute test the valve will be inspected for leakage.

The return lines will then be connected to the test fixture and the valve assembly will be subjected to 2 minutes of acceleration at 20 G in each direction along the three orthogonal axes. During each 2 minute test the fuel and oxidizer inlets will be pressurized with Mil-H-5606 hydraulic fluid at 195 psig and the valve will be subjected to the response test of paragraph 7. 1. 5, condition (b). The response test will be repeated following each axis test with no acceleration applied.

The acceleration level, 20 G, for each test will be generated at the point on the valve which is nearest the center of the centrifuge.

After completion of all of the acceleration tests the valve assembly will be subjected to an interval performance test..

6.2.5 Shock Test

The valve, mounted on a test fixture, will be subjected to a total of 18 shocks. The shocks will be applied, three in each direction, along the three major axes. The shock pulse will be a half sine wave of ten (10) milliseconds duration at a peak magnitude of 20 G. The valve will be filled and pressurized to the upstream valves with Mil-H-5606 hydraulic fluid at 151 psig during the shock test.

After completion of the last axis test the valve assembly will be subjected to an interval performance test.

6.2.6 Handling Shock

The valve will be subjected to four 45° pivot drops and a one (1) inch free fall drop to a hardwood bench top on each face of the valve. The valve will then be subjected to an interval performance test.

6.2.7 Life Test

The quadredundant valve will be subjected to a life test which will continue until 50,000 cycles of operation are accumulated. The cycling portions of the life test will be performed on the water test system and the minimum valve cycling rate will be 10 cps. After each 10,000 cycles of operation the valve will be subjected to an interval performance test. All cycling will be accomplished with a supply pressure of 310 psig. During the interval performance tests the valve will be subjected to 100 cycles of dry valve operation between leakage tests.

6.2.8 Fuel Compatibility Test

This test will be conducted to Thiokol Chemical Corporation, Reaction Motors Division, Denville, New Jersey. After completion of this test, Moog will conduct an interval performance check on the valve.

6.2.9 Oxidizer Compatibility Test

This test will be conducted by Thiokol Chemical Corporation, Reaction Motors Division, Denville, New Jersey. After completion of this test, Moog will conduct an interval performance check on the valve.

6.2.10 Vacuum Test

The quadredundant valve will be installed in an altitude chamber and electrical connections will be made to permit energizing the valve coils. Prior to reducing chamber pressure to 10^{-6} mm. of Hg., immediately after reducing chamber pressure, at 5 day intervals, and during the last hour at altitude, the bipropellant valve will be subjected to the following test.

Each coil will be energized by increasing the voltage from zero (0) vdc at a slow, uniform rate (5-15 volts per minute), to 33 vdc. The voltage at which the valve opens will be recorded. The 33 vdc will be maintained for five (5) minutes and will then be decreased at a slow uniform rate (5-15 volts per minute) until the valve closes. The voltage at which the valve closes will be recorded. The valve will then be cycled open-close 100 times while varying the voltage from 20 to 33 vdc. While the coils are still hot from cycling, the valve will be subjected to a dielectric strength test. Arc over or current flow in excess of 50 microamperes will constitute a failure. The total time at altitude will be a minimum of 346 hours.

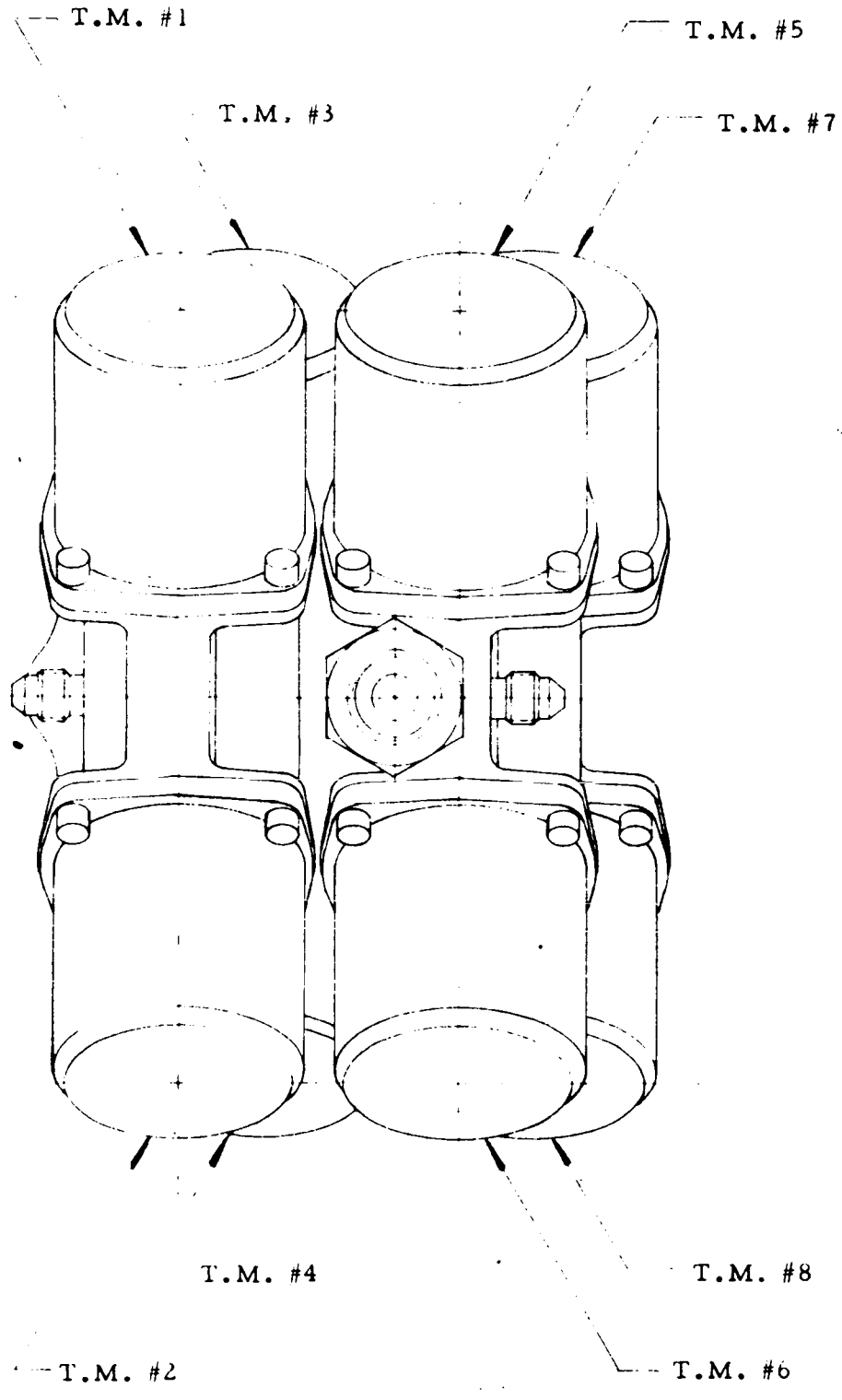
6.2.11 Electrical Interference Test

An electrical interference test will be conducted by Thiokol Chemical Corporation, Reaction Motors Division, Denville, New Jersey.

6.2.12 Burst Test

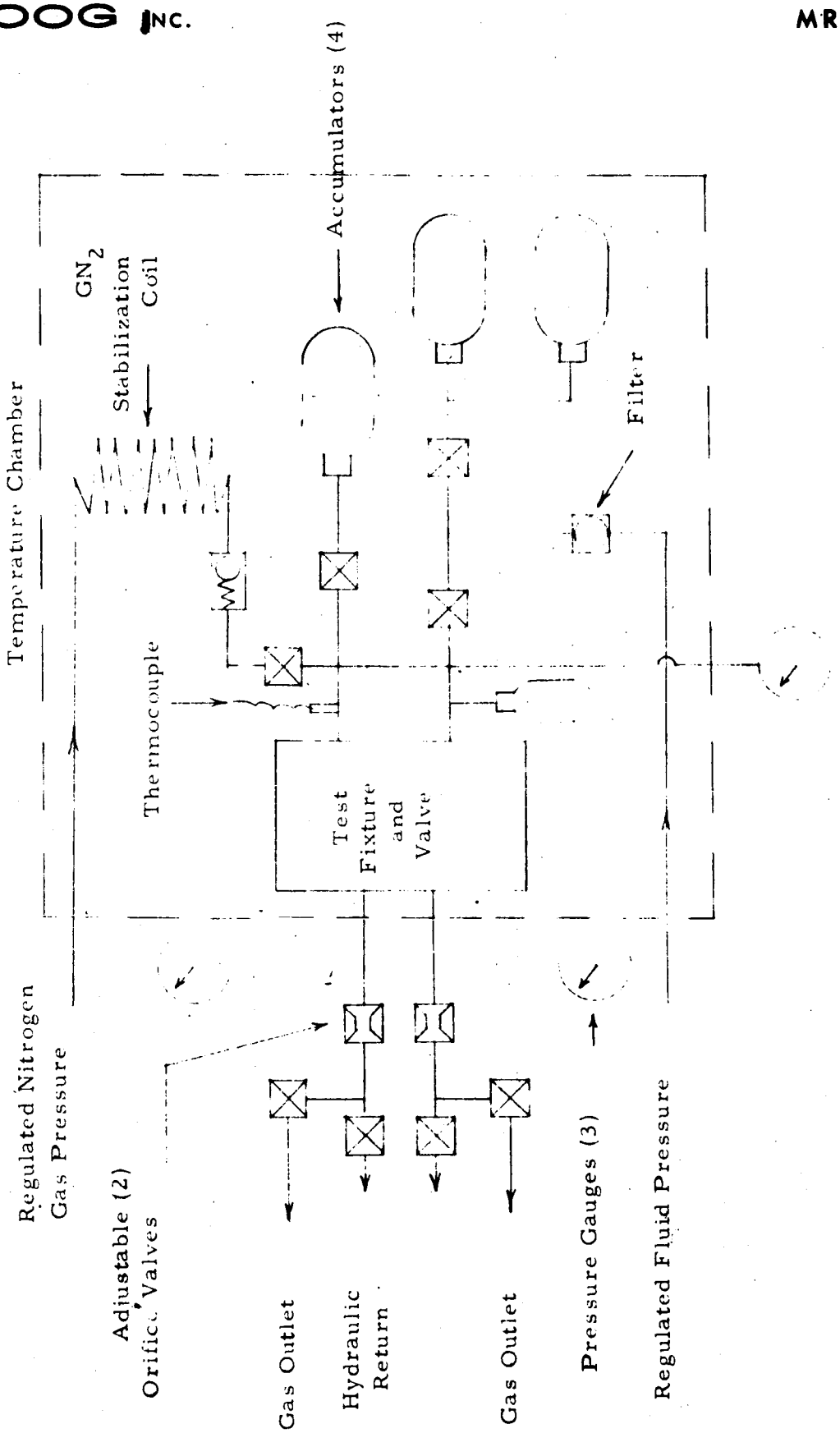
The burst pressure test will be conducted using Mil-H-5606 hydraulic fluid as the pressurizing medium. The valve coil covers will be removed to ascertain the earliest possible failure, i.e., the armature flexure sleeves are the most suspect. With the inlet ports to the valve assembly capped off, hydraulic fluid

at 1150 psig will be applied to the valve assembly outlet ports. The pressure will be maintained at 1150 psig for 2 minutes. The valve assembly will then be inspected for deformation and/or evidence of leakage or failure. The pressure will then be slowly increased until failure occurs. The maximum pressure attained and the mode of failure will be reported on the test data sheet.



Torque Motor Pairs: 1 & 5, 2 & 6, 3 & 7, 4 & 8

Figure 1 - Quad-Redundant Valve



Schematic - Temperature Test Setup

Figure 2

INITIAL/FINAL PERFORMANCE

Model Number 50-304
Serial Number _____
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
Examination of product	6. 1. 1	Visually inspect the conformance to applicable drawings with respect to material. workmanship. finish. and markings. Measure dry weight	≤8. 6 lbs.	_____
Proof Pressure	6. 1. 2			
a. Valve assembly	6. 1. 2. 1	Apply 720 psig to inlet and outlet ports for two minutes. No electrical signal. monitor for evidence of permanent set. distortion. and external leakage.	No distortion or External Leakage	_____
b. Seat Assembly	6. 1. 2. 2	Vent outlet to atmosphere. No electrical signal. Apply 720 psig to inlets for two minutes. Observe for external leakage. If leakage occurs. measure leakage rate.		_____
Electrical Resistance	6. 1. 3			Temp. _____ °F
a. Coil resistance	6. 1. 3. 1	Measure and record the resistance of each coil. Record the existing ambient temperature.	21. 85 to 24. 15 ohms corrected to 77° F	DF _____ LN _____ UW _____ ZP _____ AC _____ HK _____ RT _____ GY _____

INITIAL/FINAL PERFORMANCE

Model Number 50-304
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Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
(b) Insulation Resistance	6. 1. 3. 2	Apply 500 vdc between each coil and valve body. Record the insulation resistance, in megohms.	>100 megohms	DF _____ LN _____ UW _____ ZP _____ AC _____ HK _____ RT _____ GY _____
		Apply 500 vdc between each coil and all other coils. Record the insulation resistance, in megohms.	>100 megohms	DF _____ LN _____ UW _____ ZP _____ AC _____ HK _____ RT _____ GY _____
Dielectric Strength	6. 1. 4	Apply 1000 vac at 60cps to: 1) All coils to case 2) All coils to connector Record the leakage current	< 50 ma	1) _____ 2) _____
Response Test	6. 1. 5 (a)	Individual motors with the other motor common to that series leg energized open Inlet pressure 195 psig Excitation 22 vdc Hot Amps Vertical 0. 2 amps/cm. Horizontal 5 ms/cm.	ON: 14 msec OFF: 14 msec	Open / Close 1 _____ / _____ 2 _____ / _____ 3 _____ / _____ 4 _____ / _____ 5 _____ / _____ 6 _____ / _____ 7 _____ / _____ 8 _____ / _____

INITIAL/FINAL PERFORMANCE

Model Number 50-304
Serial Number _____
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
Response Test	6. 1. 5 (b)	Individual motors while all motors are being operated simultaneously with hot amps.	ON: 14 msec OFF: 14 msec	Open / Close 1 _____ _____ 2 _____ _____ 3 _____ _____ 4 _____ _____ 5 _____ _____ 6 _____ _____ 7 _____ _____ 8 _____ _____
Flow Test	6. 1. 6 (a)	Measure flow and pressure drop with inlet pressure of 195 psig. Both Series Legs Flowing.	Maximum drop at rated flow: Fuel - 11 psid Oxidizer - 14 psid	

Fuel		Oxidizer	
Press Drop	Flow lbs/sec	Press Drop	Flow lbs/sec
5	_____	7	_____
10	_____	12	_____
15	_____	17	_____
	0. 144		0. 179

6.1.6 (b)	One series leg open. oxidizer and fuel		Fuel 31 psid Oxidizer 40 psid

Fuel 1 & 3		Oxidizer 5 &7	
Press Drop	Flow lbs. / sec.	Press Drop	Flow lbs. / sec.
15	_____	20	_____
20	_____	25	_____
25	_____	30	_____
30	_____	35	_____
35	_____	40	_____
_____	0. 144	_____	0. 179

INITIAL/FINAL PERFORMANCE

Model Number 50-304
Serial Number _____
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
Flow Test	6. 1. 6 (c)	One series leg open oxidizer and fuel.	Fuel: 31 psid / Oxidizer 40 psid	

Fuel 2 & 4		Oxidizer 6 & 8	
Press Drop	Flow lbs. / sec.	Press Drop	Flow lbs. / sec.
15	_____	20	_____
20	_____	25	_____
25	_____	30	_____
30	_____	35	_____
35	_____	40	_____
	0. 144		0. 179

Functional Test	6. 1. 7			
Pull In Voltage	6. 1. 7. 1	Inlet pressure at 325 psig minimum voltage required for three on-off cycles	<20vdc	
	6. 1. 7. 1 (a)	Individual motors with the other motor common to that series leg energized open with a minimum voltage (5 to 10) vdc.		1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
	6. 1. 7. 1 (b)	Individual motors while operating in parallel pairs. Motors common to the series legs will be energized open with a minimum voltage (5 to 10) vdc.	<20 vdc	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____

INITIAL/FINAL PERFORMANCE

Model Number 50-304
Serial Number _____
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
Drop Out Voltage	6. 1. 7. 2	Inlet pressure 166 psig measure maximum voltage at which valve closes		
	6. 1. 7. 2	Individual motors with all other motors energized at 26 vdc	Indicate drop-out voltage or that the motor does not drop out	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
	6. 1. 7. 2 (b)	Individual motors while operating in parallel pairs. Motors common to the series legs will be energized open with 5-10 vdc.	>1. 0 volt	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
	6. 1. 7. 2 (c)	Inlet pressure 5 psig nitrogen gas. Individual motors with the other motor common to that series leg energized open with 5-10 vdc.	>1. 0 volt	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
External Leakage Test	6. 1. 8	Inlet pressure 325 psig helium	$<10^{-4}$ cc/sec. Fuel Oxidizer	_____ cc/sec. _____ cc/sec.

INITIAL/FINAL PERFORMANCE

Model Number 50-304
Serial Number _____
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
Internal Leakage	6. 1. 9	Inlet pressure at 50 psig	<5 cc/hr.	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
	6. 1. 9	Inlet pressure at 325 psig		1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
		Apply 10 cycles		_____
	6. 1. 9	Inlet pressure at 50 psig		1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
	6. 1. 9	Inlet pressure at 325 psig		1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____

INITIAL/FINAL PERFORMANCE

Model Number 50-304
Serial Number _____
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
Reverse Seat Leakage Test	6.1.9	Apply 20 psig to the outlet ports. Open either the upstream or downstream valve and measure the leakage across the other valve. Repeat for each valve	<30 cc/ hr. per seat	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____

INTERVAL PERFORMANCE

Model Number 50-304
Serial Number _____
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
Coil Resistance	6.1.3.1	Measure and Record the resistance of each coil. Record the existing ambient temperature.	21.85 to 24.15 ohms when corrected to 77° F	Temp. _____ F DF _____ LN _____ UN _____ ZP _____ AC _____ HK _____ RT _____ GY _____
Response Test	6.1.5 (b)	Individual motors while all motors are being operated simultaneously with hot amps.	ON: 14 msec OFF: 14 msec	Open / Close 1 _____ / _____ 2 _____ / _____ 3 _____ / _____ 4 _____ / _____ 5 _____ / _____ 6 _____ / _____ 7 _____ / _____ 8 _____ / _____
Flow Test	6.1.6 (a)	Measure flow and pressure drop with inlet pressure of 195 psig Both Series Legs Flowing:	Minimum drop at rated flow: Fuel: 11 psid Oxidizer: 14 psid	

Fuel		Oxidizer	
Press Drop	Flow lbs/sec	Press Drop	Flow lbs/sec
5	_____	7	_____
10	_____	12	_____
15	_____	17	_____
_____	0.144	_____	0.179

INTERVAL PERFORMANCE

Model Number 50-304
Serial Number _____
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
Functional Test	6.1.7			
Pull In Voltage	6.1.7.1 (b)	Inlet pressure at 325 psig. measure minimum voltage required for three on-off cycles for individual motors while operating in parallel pairs. Motors common to the series legs will be energized open with a minimum voltage (5 to 10 vdc)	<20 vdc	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
Drop-out Voltage	6.1.7.2 (b)	Inlet pressure at 166 psig. Measure maximum voltage at which valve closes. Individual motors while operating in parallel pairs. Motors common to the series legs will be energized open with a minimum voltage (5 to 10 vdc).	>1.0 volts	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
External Leakage Test	6.1.8	Inlet pressure 325 psig helium	$<10^{-4}$ cc/sec. Fuel Oxidizer	_____ cc/sec _____ cc/sec

INTERVAL **PERFORMANCE**

Model Number 50-304
Serial Number _____
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
Internal Leakage	6.1.9	Inlet pressure at 50 psig	<5 cc/hr.	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
	6.1.9	Inlet pressure at 350 psig		1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
		Apply 10 cycles		_____
	6.1.9	Inlet pressure at 50 psig		1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____
	6.1.9	Inlet pressure at 325 psig		1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____

INTERVAL **PERFORMANCE**

Model Number 50-304
Serial Number _____
Date _____

Specimen Designation Letter _____
Tested By: _____
On Time _____ Cycles _____

Test	Proc. Par. No.	Conditions & Measurements	Limits	Test Results
Reverse Seat Leakage Test	6.1.9	Apply 20 psig to the outlet ports. Open either the upstream or downstream valve and measure the leakage across the other valve. Repeat for each valve	<30 cc/ hr. per seat.	1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____

Thiokol
REACTION MOTORS DIVISION

APPENDIX L

PART II
QUADREDUNDANT VALVE
QUALIFICATION TEST REPORT

MOOG MR 1207

QUALIFICATION TEST REPORT

FOR

VALVE, QUADREDUNDANT, ELECTRICAL

TORQUE MOTOR OPERATED, PULSE MODULATED

MOOG MODEL 50-304

Thiokol Chemical Corporation
Reaction Motors Division
Part No. 317013-500

MOOG INC.
Report No. MR 1207

Prepared by: _____
G. B. Le Roy
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Approved by: _____
D. P. Elmer
Manager, Reliability
Engineering

Date: June 29, 1967

ABSTRACT

The Qualification Test Program documented by this report was initiated on May 3, 1967. The program was administered by the Reliability Engineering Group of Moog Inc., at East Aurora, New York and was authorized by Thiokol Chemical Corporation, Reaction Motors Division, Denville, New Jersey, Purchase Order B86716. The program was conducted to satisfy the requirements of Thiokol Chemical Corporation Specification Number EC 20518 Revision G. The test program was completed on May 25, 1967.

REFERENCES

1. "Quadredundant Valve Assembly, Detail Specification for," Thiokol Chemical Corporation, Reaction Motors Division, Denville, New Jersey, Specification Document EC-20518, Revision G, dated May 10, 1967.

2. "Qualification Test Procedure for Quadredundant Valve Assembly, Torque Motor Operated, Pulse Modulated, Moog Model 50-304."

TABLE OF CONTENTS

1.0 INTRODUCTION

This report documents the Qualification Test Program conducted on Moog Model 50-304 quadredundant valve, Thiokol Chemical Corporation, Reaction Motors Division part number 317013-500. The test program was conducted using the facilities of the Moog Reliability Engineering Laboratory at East Aurora, New York, and the Dayton T. Brown Testing Laboratory at Bohemia, Long Island, New York.

The Model 50-304 quadredundant valve is a torque motor operated, flapper-nozzle valve designed to simultaneously meter fuel and oxidizer flow at a given pressure drop. The Qualification Test Program was conducted to demonstrate that the design integrity and basic functional parameters of the valve design are compatible with the requirements of TCC-RMD specification EC-20518, Revision G.

2.0 TEST SPECIMEN

Six test specimens, typical of production configuration, were subjected to the Qualification Test Program. The valve serial numbers were 125, 126, 127, 129, and 130. Two of the units, S/N 125 and S/N 130, had been used for other testing prior to their use as qualification specimens. Utilization of these units was necessitated by the "tight" scheduling delegated to the Qualification Test Program. Valve S/N 125 had been life cycled to 50,000 cycles during the Development Test Program and was reacceptance tested prior to qualification testing. Valve S/N 130 had completed pre-qualification sinusoidal and random vibration and shock testing prior to incorporation into the Qualification Test Program. Test history accumulated on specimen 130, prior to vacuum testing, is not included in this report because all other testing was conducted by TCC-RMD.

3.0 TEST PROGRAM

The test program consisted of performance and environmental testing in accordance with the applicable Thiokol Specification Number EC-20518 Revision G. An outline of the test program format is presented on the following page.

Test	Test Specimen				
	125	126	127	129	130
Acceptance Test	X	X	X	X	X
Temperature Test				X	
Handling Shock			X		
Life Test		X	X		
Vacuum					X
Final Performance		X	X	X	X
Burst Test	X				

4.0 SUMMARY

The test specimen quadredundant valves successfully completed all environmental and post environmental performance tests with the exception of the life cycle test. Two flexure sleeve failures occurred on each of the life cycle specimens, S/N 126 and S/N 127. These failures demonstrated the inadequacy of the existing flexure sleeve design to provide sufficient life capability.

5.0 DISCUSSION OF TEST FAILURES AND/OR DISCREPANCIES

The test failures and/or discrepancies encountered during the Qualification Test Program are described in the following paragraphs.

5.1 Flexure Sleeve Failures

Four flexure sleeve failures were incurred during the Qualification Test Program. All failures occurred during the cycling sequence of the Qualification Life Test. On test specimen S/N 126, the fuel valve flexure sleeve on torque motor number three (3) failed at 43,680 cycles and the fuel valve flexure sleeve on torque motor number one (1) failed at 53,955 cycles. On test specimen S/N 127, flexure sleeve failures were observed on fuel flexure sleeve number four (4) and oxidizer flexure sleeve number five (5) after 77,154 cycles.

A detailed investigation into the cause of these failures is presently being conducted and a failure analysis report will be submitted to TCC-RMD immediately upon completion.

5.2 Vacuum Test

Visual inspection of the test specimen, S/N 130, immediately prior to vacuum testing disclosed the existence of a bare jumper wire at the top of the electrical connector. The teflon covering at the "bare point" appeared to be cut, indicating possible damage due to handling or testing. This unit was utilized by RMD-RCC for conducting various dynamic and environmental tests prior to shipment to the Dayton T. Brown Testing Laboratories for vacuum testing. The damaged wire was tape repaired and vacuum testing was initiated on June 10, 1967.

During the last hour at vacuum the valve was subjected to a dielectric strength test. When the valve failed to meet the requirements of this test, a series of checks were conducted to determine which coils were causing the failure. The results of this investigation are as follows:

Coil	Applied Voltage	Leakage	Results
1	600	4 a	intermittent arcing
2	600	1 a	no arcing
3	460	short	-
4	520	short	-
5	600	1 a	no arcing
6	500	short	-
7	475	short	-
8	600	5 a	no arcing

A failure analysis is presently being conducted on this valve and a report will be submitted to TCC-RMD as soon as possible.

6.0 SPECIMEN TEST HISTORY

The chronological sequence of testing to which each specimen was subjected including test name, test date, on time and cycles during each test, and total cycles and on time accumulated, are presented on the following pages.

QUALIFICATION TEST

Moog Model 50-304
Serial Number 125

Test History

Test	Date	On Time this Test			Cycles this test	Total On Time			Total No. Cycles
		Hr.	Min.	Sec.		Hr.	Min.	Sec.	
Development Testing	1/21/67	—	—	—	—	28	3	36	59,701
Acceptance Test	5/3/67	10	4	—	1880	38	7	36	61,581
Burst Test	6/1/67	—	—	—	—	38	7	36	61,581

QUALIFICATION TEST

Moog Model 50-304
Serial Number 126

Test History

Test	Date	On Time this Test			Cycles this test	Total On Time			Total No. Cycles
		Hr.	Min.	Sec.		Hr.	Min.	Sec.	
Acceptance Test	4/14/67	20	42	58	3,272	20	42	58	3,272
Life Phase I	5/4/67	—	18	—	10,000	21	—	58	13,272
Post Phase I	5/5/67	—	43	20	210	21	44	18	13,482
Life Phase II	5/5/67	—	20	—	10,000	22	4	18	23,482
Post Phase II	5/6/67	—	34	5	156	22	38	23	23,638
Life Phase III	5/6/67	—	20	—	10,000	22	58	23	33,638
Post Phase III	5/8/67	—	33	41	161	23	32	4	33,799
Life Phase IV	5/8/67	—	20	—	9,881	23	52	4	43,680
Post Phase IV	5/9/67	—	33	10	154	24	25	14	43,834
Life Phase V	5/10/67	—	23	—	10,121	24	48	14	53,955

QUALIFICATION TEST

Moog Model 50-304
Serial Number 127

Test History

Test	Date	On Time this Test			Cycles this test	Total On Time			Total No. Cycles
		Hr.	Min.	Sec.		Hr.	Min.	Sec.	
Acceptance	4/12/67	23	52	—	5,243	23	52	—	5,243
Handling Shock	5/3/67	—	—	—	—	23	52	—	5,243
Post Handling Shock	5/4/67	—	57	12	238	24	50	12	5,481
Life Phase I	5/4/67	—	20	—	10,000	25	10	12	15,481
Post Phase I	5/5/67	—	35	35	144	25	45	47	15,625
Life Phase II	5/5/67	—	21	—	10,000	26	6	47	25,625
Post Phase II	5/6/67	—	35	55	131	26	42	42	25,756
Life Phase III	5/6/67	—	20	—	10,000	27	2	42	35,756
Post Phase III	5/8/67	—	34	5	150	27	36	47	35,906
Life Phase IV	5/8/67	—	20	—	10,000	27	56	47	45,906
Post Phase IV	5/9/67	—	33	55	154	28	30	42	46,060
Life Phase V	5/9/67	—	21	—	10,000	28	51	42	56,060
Final Performance	5/15/67	2	55	—	269	31	46	42	56,329
Life Test Continued Post Life 70,825 ~	5/17/67	—	38	—	20,825	32	24	42	77,154

QUALIFICATION TEST

Moog Model 50-304
Serial Number 129

Test History

Test	Date	On Time this Test			Cycles this test	Total On Time			Total No. Cycles
		Hr.	Min.	Sec.		Hr.	Min.	Sec.	
Acceptance Test	5/10/67	10	30	—	3500	10	30	—	3500
+180°F Temp. Test	5/11/67	—	56	15	270	11	26	15	3770
Post +180°F Temp. Test	5/11/67	—	46	45	275	12	13	—	4045
+12°F Temp. Test	5/12/67	—	42	15	208	12	55	15	4253
Post +12°F Temp. Test	5/15/67	—	47	30	225	13	42	45	4478

QUALIFICATION TEST

Moog Model 50-304
Serial Number 130

Test History

Test	Date	On Time this Test			Cycles this test	Total On Time			Total No. Cycles
		Hr.	Min.	Sec.		Hr.	Min.	Sec.	
Acceptance	5/22/67	11	55	12	5021	11	55	12	5021

7.0 TEST RESULTS AND TEST DATA

7.1 Acceptance Test

Each of the test specimen valves was subjected to an Acceptance Test as described in Moog Report Number MR 1117, Revision A. The test results are included on the tabulated data sheets in Section 8.0 of this report. All results were satisfactory.

Three of the qualification test specimens, S/N 125, S/N 126, and S/N 127 were acceptance tested to Revision F of TCC-RMD Specification EC-20518 and two of the specimens, S/N 129 and S/N 130, to Revision G. This inconsistency is reflected in the tabulated data since all subsequent testing conducted on these specimens is performed in accordance with Revision G.

7.2 Temperature Test

Test specimen S/N 129 was subjected to the temperature test of paragraph 6.2.1 of reference 2. Test specimen performance was satisfactory, with the results tabulated in Section 8.0.

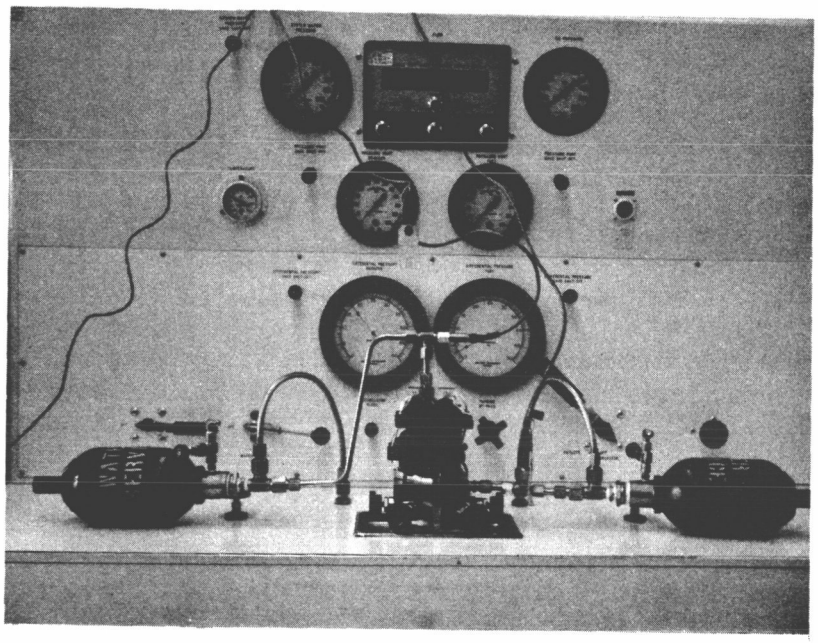
While at the test temperatures of +12 F and +180 F and with a pressure and voltage of 325 psig and 20 vdc respectively applied to the valve, the unit must be capable of opening. As recorded in the tabulated data, the valve operated satisfactorily when subjected to these conditions.

7.3 Handling Shock

Test specimen S/N 127 was subjected to the handling shock test as described in paragraph 6.2.6 of reference 2. The post shock interval performance test results were all satisfactory and are presented in Section 8.0.

7.4 Life Test

Two of the test specimen quadredundant valves, serial numbers 126 and 127, were subjected to the qualification life test as described in paragraph 6.2.7 of reference 2. The results of the interval performance tests conducted after each 10,000 cycle increment are included on the tabulated data sheets in Section 8.0.



LIFE TEST

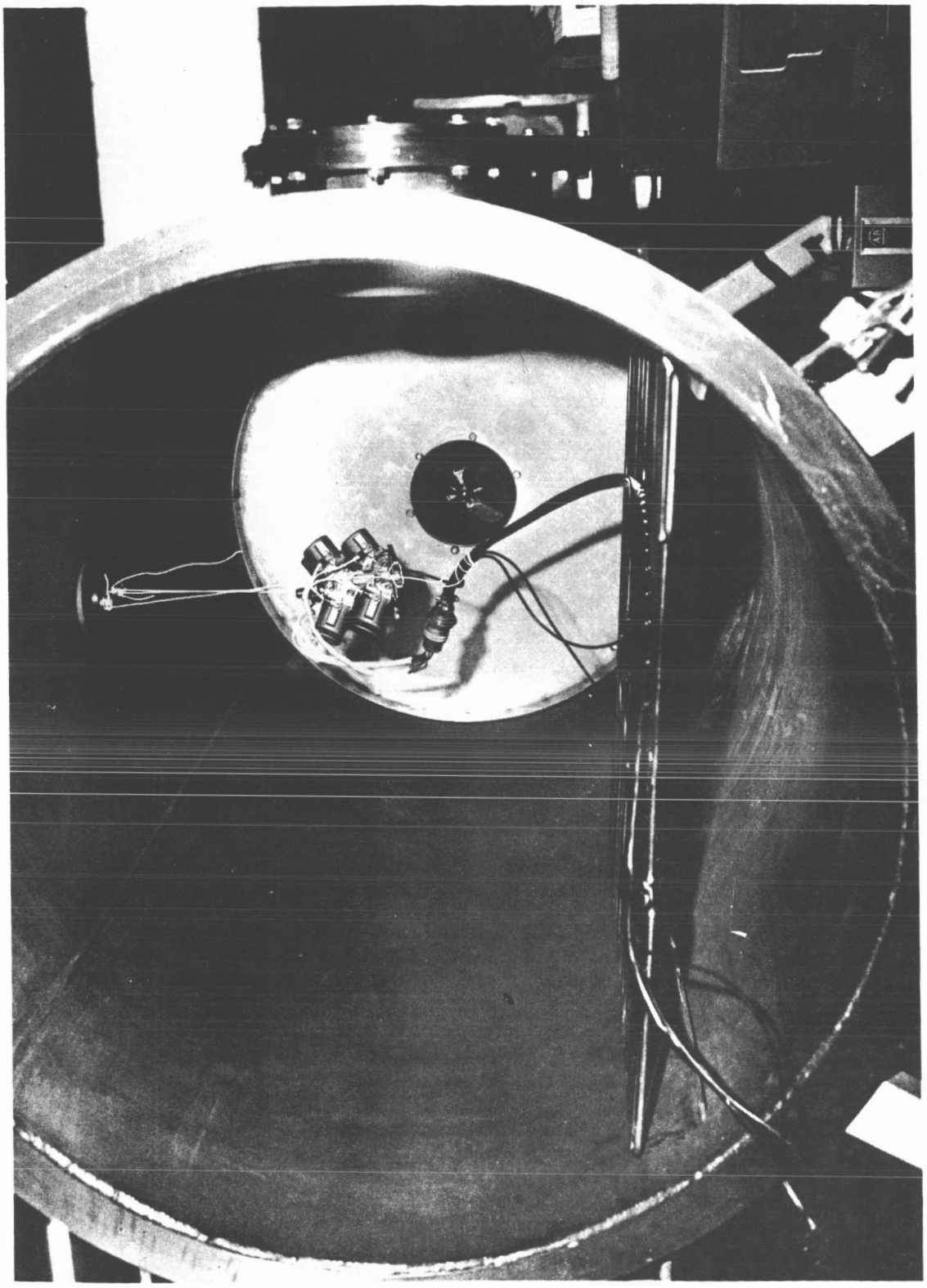
Valve S/N 126 incurred a flexure sleeve failure after 43,680 cycles of operation. In order to evaluate the capability of other valve components and performance parameters to meet the life requirement; cycling was continued to 53,955 cycles with the failed torque motor energized open. At the completion of life cycling, a second flexure sleeve was found broken. The flexure sleeve failures occurred on the fuel valve torque motors numbers one and three.

Valve S/N 127 completed the 50,000 cycle life requirement with no indication of performance degradation. In order to help demonstrate ample safety margin for all valve design and performance parameters, life cycling was continued. After 77,154 cycles of operation, two broken flexure sleeves were discovered; one fuel and one oxidizer. A discussion of all flexure sleeve failures has been presented in paragraph 5.1 of this report.

7.5 Vacuum Test

Test specimen serial number 130 was subjected to the vacuum test at the Dayton T. Brown Testing Laboratories, Bohemia, Long Island, New York. The test was started on June 10, 1967, and completed on June 26, 1967. The test data recorded while the valve was in the vacuum environment, and the results of the post vacuum interval performance test show no degradation of pull-in voltage drop-out current and insulation resistance due to the environment. However, the unit failed to pass the dielectric strength test in the vacuum environment. The valve was installed in the vacuum chamber as shown in the photograph following, and was subjected to 336 hours at a maximum pressure of 10^{-6} mm Hg. Prior to reducing chamber pressure, shortly after reducing chamber pressure, at five day intervals, and during the last hour at altitude, the valve was subjected to the following test sequence. Each coil of the valve was energized by slowly increasing the voltage from 0 to 30 vdc. The 30 vdc was maintained for five (5) minutes and then decreased slowly until the valve closes. The energizing (pull-in) and de-energizing (drop-out) voltages were recorded. The valve was then cycled 100 times while the coil voltage was varied from 20 to 30 vdc. While the coils were still hot from cycling, the valve was subjected to the insulation resistance test. The values for the pull-in and drop-out voltage test and the insulation resistance test are included in the following table.

During the last hour at altitude the valve was subjected to a dielectric strength test. The values for this test are included in the following table. A discussion of the test failure has been presented in paragraph 5.2 of this report.



VACUUM TEST

VACUUM TEST DATA

Model 50-304
Serial No. 130
Date 6/10/67

Pre-Altitude

Torque Motor Number	Pull-in		Drop-out		Insulation Resistance		Dielectric Strength	
	Voltage	Current	Voltage	Current	Each coil to valve body	Each coil to other 7 coils	Parallel coil leads & valve assembly	Parallel coil leads & connector
1	4.41	.19	2.41	.07	∞	∞	Not Applicable	Not Applicable
2	5.82	.25	2.98	.08				
3	5.63	.24	3.82	.12				
4	4.42	.19	2.78	.08				
5	3.77	.16	1.94	.05				
6	6.66	.28	1.64	.05				
7	7.12	.30	2.79	.08				
8	4.05	.17	1.84	.05				

VACUUM TEST DATA

Model 50-304
Serial No. 130
Date 6/12/67

Torque Motor Number	Pull-in		Drop-out		Insulation Resistance		Dielectric Strength	
	Voltage	Current	Voltage	Current	Each coil to valve body	Each coil to other 7 coils	Parallel coil leads & valve assembly	Parallel coil leads & connector
1	4.39	.19	2.21	.06	∞	∞	Not Applicable	Not Applicable
2	5.61	.23	2.76	.08				
3	5.62	.24	4.10	.12				
4	4.32	.18	2.68	.08				
5	3.76	.16	1.83	.05				
6	6.74	.28	1.65	.05				
7	7.30	.31	2.40	.07				
8	3.95	.16	2.12	.06				

VACUUM TEST DATA

Model 50-304
Serial No. 130
Date 6/17/67

Torque Motor Number	Pull-in		Drop-out		Insulation Resistance		Dielectric Strength	
	Voltage	Current	Voltage	Current	Each coil to valve body	Each coil to other 7 coils	Parallel coil leads & valve assembly	Parallel coil leads & connector
1	4.18	.17	2.14	.06			Not Applicable	Not Applicable
2	5.90	.24	3.19	.09				
3	5.73	.24	3.69	.10				
4	4.57	.19	2.76	.08				
5	3.72	.15	1.96	.05				
6	6.90	.28	1.86	.05				
7	7.36	.30	2.30	.06				
8	4.14	.17	2.12	.06				

VACUUM TEST DATA

Model 50-304
Serial No. 130
Date 6/22/67

Torque Motor Number	Pull-in		Drop-out		Insulation Resistance		Dielectric Strength	
	Voltage	Current	Voltage	Current	Each coil to valve body	Each coil to other 7 coils	Parallel coil leads & valve assembly	Parallel coil leads & connector
1	4.09	.18	2.18	.06			Not Applicable	Not Applicable
2	5.49	.24	2.84	.09				
3	5.49	.24	3.98	.11				
4	4.10	.15	2.88	.08				
5	3.56	.12	1.97	.06				
6	6.61	.28	1.86	.05				
7	7.07	.30	2.56	.07				
8	3.81	.16	2.20	.07				

VACUUM TEST DATA

Model 50-304
Serial No. 130
Date 6/26/67

Torque Motor Number	Pull-in Voltage	Pull-in Current	Drop-out Voltage	Drop-out Current	Insulation Resistance Each coil to valve body	Insulation Resistance Each coil to other 7 coils	Dielectric Strength Parallel coil leads & valve assembly	Dielectric Strength Parallel coil leads & connector
1	4.01	.18	2.22	.07			Arcing at 440 v	1 a at 600 v
2	5.42	.24	3.14	.09			Short at 500 v	
3	5.43	.24	4.02	.12				
4	4.27	.18	2.87	.09				
5	3.56	.15	1.90	.06				
6	6.56	.28	1.83	.05				
7	7.05	.31	2.52	.07				
8	3.87	.17	2.42	.07				

VACUUM TEST DATA

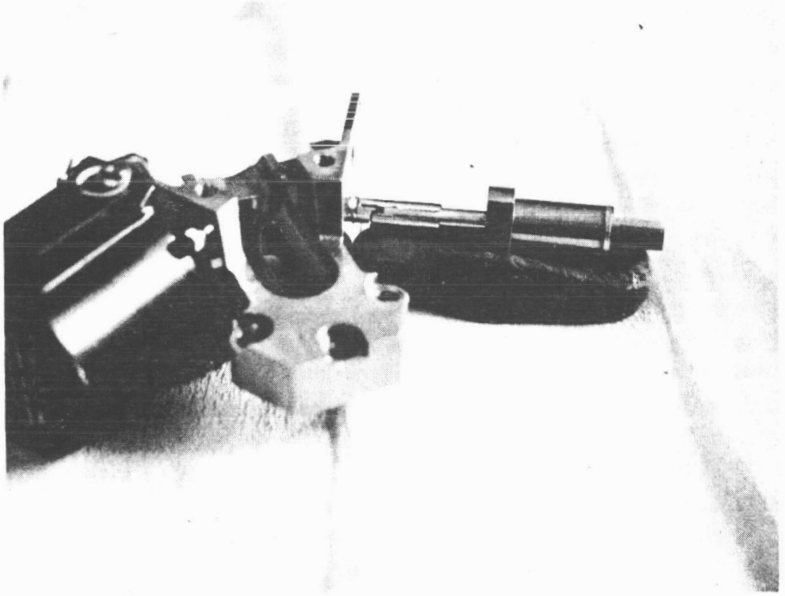
Model 50-304
Serial No. 130
Date 6/26/67

Post Vacuum

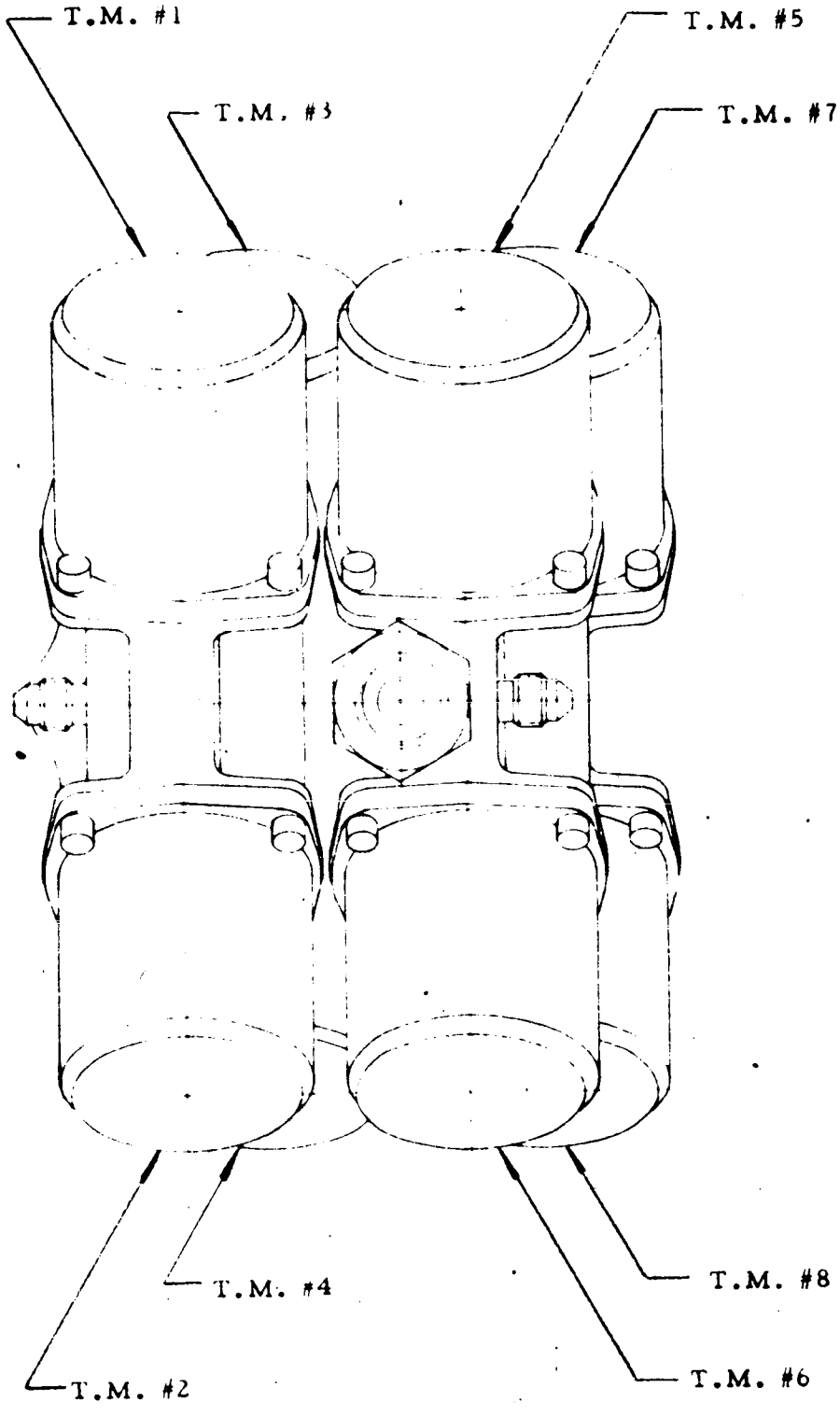
Torque Motor Number	Pull-in Voltage	Pull-in Current	Drop-out Voltage	Drop-out Current	Insulation Resistance Each coil to valve body	Insulation Resistance Each coil to other 7 coils	Dielectric Strength Parallel coil leads & valve assembly	Dielectric Strength Parallel coil leads & connector
1	4.24	.17	2.37	.07			Not Applicable	Not Applicable
2	5.64	.23	3.12	.09				
3	5.62	.24	3.94	.12				
4	4.21	.17	2.98	.09				
5	3.66	.15	2.24	.06				
6	6.80	.28	1.78	.05				
7	7.25	.30	2.46	.07				
8	3.95	.16	2.07	.06				

7.6 Burst Pressure Test

The burst pressure test was conducted on test specimen S/N 125. The test was performed as described in paragraph 6.2.12 of reference 2. The test specimen contained the test fluid at 1150 psig for two (2) minutes with no indications of deformation or evidence of external leakage. Applied pressure was then slowly increased until failure occurred. Oxidizer flexure sleeve number eight (8) burst by splitting longitudinally and circumferentially. The pressure attained immediately before failure was 8,800 psi. There was no evidence of deformation of the valve body or leakage at any of the welded joints.

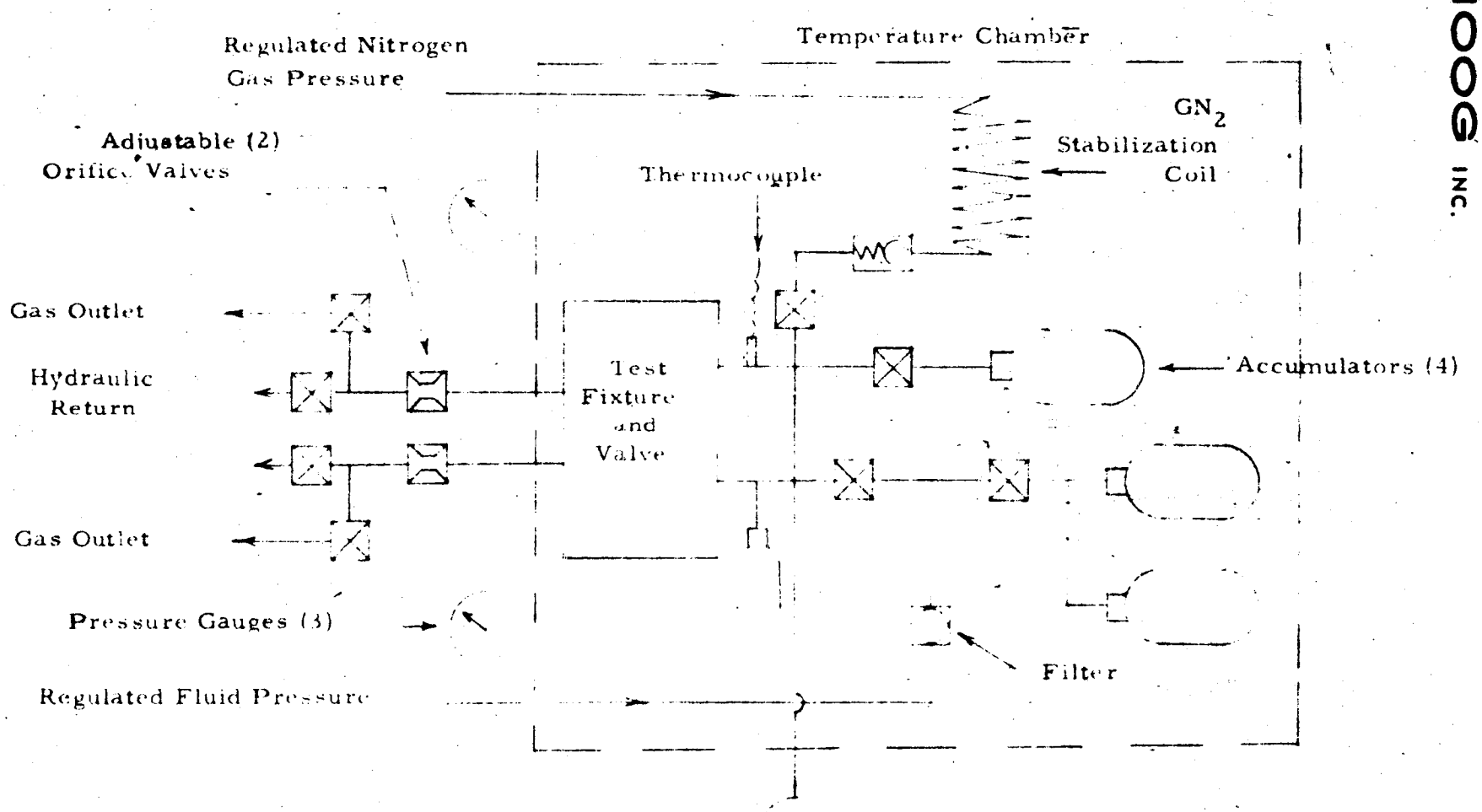


BURST PRESSURE TEST



Torque Motor Pairs: 1 & 5, 2 & 6, 3 & 7, 4 & 8

Figure 1 - Quad-Redundant Valve



Schematic - Temperature Test Setup

Figure 2

8.0 TABULATED TEST DATA

Included in this section are the results of all performance and interval performance tests conducted during the Qualification Test Program.

QUALIFICATION TEST

Model No. 50-304

Serial No. 125

Test			Results	
1.	Examination of product	Valve assembly	ok	
		Weight	8.426	
2.	Proof pressure	Valve assembly	ok	
		Seat assembly	ok	
3.	Electrical resistance	Coil resistance		
		1	22.9	
		2	22.8	
		3	22.2	
		4	22.2	
		5	22.3	
		6	22.3	
		7	22.4	
		8	22.3	
4.	Insulation resistance	Each coil to valve body		
		1	4500	
		2	4300	
		3	7000	
		4	7000	
		5	10000	
		6	9000	
		7	11000	
		8	11000	
5.	Response	Condition b	on	off
		1	5	12
		2	5	11
		3	7.5	8
		4	8	6
		5	8.5	6.5
		6	8.5	7
		7	5	7.5
		8	5	7.5

Test			Results
6. Functional Test	Pull-in voltage at 325 psig condition a		
		1	15.0
		2	13.4
		3	12.4
		4	12.5
		5	16.0
		6	15.1
		7	13.6
		8	13.6
	Drop-out voltage at 5 psig condition c		
		1	1.2
		2	1.7
		3	1.3
		4	2.0
		5	2.2
		6	1.7
		7	1.6
		8	1.9
7. Flow Test	Both series legs flowing		9.6 11.2
	One series leg open, 1 & 3, 5 & 9		25.3 34.2
	One series leg open, 2 & 4, 6 & 8		25.6 31.4
8. External leakage	at 325 psig.	Fuel	4.0×10^{-6}
		Ox.	4.0×10^{-6}
9. Internal leakage	at 50 psig	1	1.0
		2	
		3	—
		4	—
		5	1.0
		6	
		7	—
		8	—

Test			Results
	at 325 psig	1	4.5
		2	
		3	—
		4	—
		5	5.0
		6	
		7	—
		8	—
	100 cycles at 50 psig	1	—
		2	—
		3	—
		4	—
		5	—
		6	—
		7	—
		8	—
	at 325 psig	1	—
		2	—
		3	—
		4	—
		5	
		6	—
		7	—
		8	—

QUALIFICATION TEST
Model 50-304
Serial Number 126

				Acceptance Test Data Prototype as/ (ATP)	Post Phase I of Life (10,000 ~)	Post Phase II of Life (20,000 ~)	Post Phase III of Life (30,000 ~)	Post Phase IV of Life (39,881 ~)						
		Date		4/14/67	5/4/67	5/6/67	5/8/67	5/9/67						
		Limits	Coil											
Examination of	Visual Inspection			ok	–	–	–	–						
Product	Weight			8.50 lbs.	–	–	–	–						
Proof Pressure	Valve Assembly			ok	–	–	–	–						
	Seat Assembly			ok	–	–	–	–						
Electrical Resistance	Coil Resistance		DF 1	22.1	–	–	–	–						
			LN 2	22.2	–	–	–	–						
			UW 3	22.1	–	–	–	–						
			ZP 4	22.2	–	–	–	–						
			AC 5	22.2	–	–	–	–						
			HK 6	22.0	–	–	–	–						
			RT 7	22.6	–	–	–	–						
			GY 8	22.5	–	–	–	–						
				Megohms										
Insulation Resistance	Each to Valve	> 100	DF 1	80,000	–	–	–	–						
	Body	megohms	LN 2	100,000	–	–	–	–						
		at 500	UW 3	200,000	–	–	–	–						
	(Condition a)	vdc	ZP 4	150,000	–	–	–	–						
			AC 5	180,000	–	–	–	–						
			HK 6	190,000	–	–	–	–						
			RT 7	200,000	–	–	–	–						
			GY 8	150,000	–	–	–	–						
				Megohms										
	Each Coil to All	> 100	DF 1	50,000	–	–	–	–						
	Other Coils	megohms	LN 2	45,000	–	–	–	–						
		at 500	UW 3	70,000	–	–	–	–						
	(Condition b)	vdc	ZP 4	40,000	–	–	–	–						
			AC 5	50,000	–	–	–	–						
			HK 6	42,000	–	–	–	–						
			RT 7	50,000	–	–	–	–						
			GY 8	40,000	–	–	–	–						
Dielectric Strength	All Coils to Case	< 100 a		56 μa	–	–	–	–						
	All Coils to Conn	at 1000va		1.0 μa	–	–	–	–						

QUALIFICATION TEST
Model 50-304
Serial Number 126

* Broken Flexure Sleeve

				Acceptance Test Data Prototype as/ (ATP)		Post Phase I of Life (10,000∿)		Post Phase II of Life (20,000∿)		Post Phase III of Life (30,000∿)		Post Phase IV of Life (39,881∿)	
		Date		4/14/67		5/4/67		5/6/67		5/8/67		5/9/67	
		Limits	Coil	On	Off	On	Off	On	Off	On	Off	On	Off
Response Test	(Condition a)		1	—	—	—	—	—	—	—	—	—	—
			2	—	—	—	—	—	—	—	—	—	—
			3	—	—	—	—	—	—	—	—	—	—
			4	—	—	—	—	—	—	—	—	—	—
			5	—	—	—	—	—	—	—	—	—	—
			6	—	—	—	—	—	—	—	—	—	—
			7	—	—	—	—	—	—	—	—	—	—
			8	—	—	—	—	—	—	—	—	—	—
	(Condition b)		1	4.5	10.5	4.5	10.0	5.5	11.5	4.5	9.5	8.5	8.0
	All Motors		2	5.0	9.0	7.0	10.0	5.0	10.0	5.0	9.5	7.0	9.5
	Operating		3	8.5	7.0	10.5	7.0	10.0	7.0	10.0	6.5	5.0	14.3
			4	9.0	5.5	8.0	6.0	9.5	7.5	10.0	5.5	8.0	7.0
			5	9.0	6.0	10.5	7.0	7.0	7.5	10.0	6.5	9.0	7.0
			6	8.1	6.0	10.0	6.5	9.0	7.5	9.5	6.0	8.5	6.0
			7	4.5	8.5	4.5	7.0	9.0	7.5	4.0	6.5	4.5	7.0
			8	4.5	9.0	4.5	9.5	5.0	9.0	4.5	9.0	4.5	9.5
Flow Test	Both Series Legs	F		10.2 psig		9.20 psig		9.70 psig		9.80 psig		9.80 psig	
	Flowing	O		12.2 psig		11.7 psig		11.8 psig		11.6 psig		12.0 psig	
	One Series Leg	F		27.0 psig		--		--		--		--	
	Open 1 & 3, 5 & 7	O		36.0 psig		--		—		—		—	
	One Series Leg	F		25.4 psig		--		—		—		—	
	Open 2 & 4, 6 & 8	O		32.1 psig		--		—		—		—	
Functional Test	Pull-in Voltage	Volts/Amps	1	13.1	—	—	—	—	—	—	—	—	—
	at 325 psig		2	12.0	—	—	—	—	—	—	—	—	—
			3	12.8	—	—	—	—	—	—	—	—	—
			4	13.8	—	—	—	—	—	—	—	—	—
	(Condition a)		5	15.4	—	—	—	—	—	—	—	—	—
			6	14.9	—	—	—	—	—	—	—	—	—
			7	14.0	—	—	—	—	—	—	—	—	—
			8	14.1	—	—	—	—	—	—	—	—	—

QUALIFICATION TEST
Model 50-304
Serial Number 126

			Acceptance Test Data as/Prototype A.T.P.		Post Phase I of Life (10,000 ~)		Post Phase II of Life (20,000 ~)		Post Phase III of Life (30,000 ~)		Post Phase IV of Life (39,881 ~)	
		Date	4/14/67		5/4/67		5/6/67		5/8/67		5/9/67	
	Limits	Coil	Volts	Amps	Volts	Amps	Volts	Amps	Volts	Amps	Volts	Amps
Functional Test Pull-In Voltage at 325 psig (Condition b)		1	–	–	–	–	–	–	–	–	–	–
		2	–	–	–	–	–	–	–	–	–	–
		3	–	–	–	–	–	–	–	–	–	–
		4	–	–	–	–	–	–	–	–	–	–
		5	–	–	–	–	–	–	–	–	–	–
		6	–	–	–	–	–	–	–	–	–	–
		7	–	–	–	–	–	–	–	–	–	–
		8	–	–	–	–	–	–	–	–	–	–
Drop Out Voltage at 166 psig (Condition a)		1	–	–	–	–	–	–	–	–	–	–
		2	–	–	–	–	–	–	–	–	–	–
		3	–	–	–	–	–	–	–	–	–	–
		4	–	–	–	–	–	–	–	–	–	–
		5	–	–	–	–	–	–	–	–	–	–
		6	–	–	–	–	–	–	–	–	–	–
		7	–	–	–	–	–	–	–	–	–	–
		8	–	–	–	–	–	–	–	–	–	–
Drop Out Voltage at 166 psig (Condition b)		1	Does	Not	–	–	–	–	–	–	–	–
		2	Does	Not	–	–	–	–	–	–	–	–
		3	Does	Not	–	–	–	–	–	–	–	–
		4	Does	Not	–	–	–	–	–	–	–	–
		5	Does	Not	–	–	–	–	–	–	–	–
		6	Does	Not	–	–	–	–	–	–	–	–
		7	Does	Not	–	–	–	–	–	–	–	–
		8	Does	Not	–	–	–	–	–	–	–	–
Drop Out Voltage (Condition c)	Volts/ Amps	1	1.8	–	–	–	–	–	–	–	–	–
		2	2.0	–	–	–	–	–	–	–	–	–
		3	1.9	–	–	–	–	–	–	–	–	–
		4	2.5	–	–	–	–	–	–	–	–	–
		5	2.0	–	–	–	–	–	–	–	–	–
		6	2.3	–	–	–	–	–	–	–	–	–
		7	1.7	–	–	–	–	–	–	–	–	–
		8	1.6	–	–	–	–	–	–	–	–	–

QUALIFICATION TEST
Model 50-304
Serial Number 126

				Acceptance Test Data as/Prototype A.T.P.	Post Phase I of Life (10,000+)	Post Phase II of Life (20,000+)	Post Phase III of Life (30,000+)	Post Phase IV of Life (39,881+)
* Broken Flexure Sleeve		Date		4/14/67	5/4/67	5/6/67	5/8/67	5/9/67
External Leakage	Helium Gas	Limits Coil Fuel		1.8×10^{-6}	**None	**None	**None	**Fail
at 325 psig		Oxidizer		2.1×10^{-6}	**None	**None	**None	**None
Internal Leakage	at 50 psig nitrogen	cc/hr.	1	3.0	0	0	0	0
			2					
			3	0	0	0	0	0*
			4					0
			5	3.5	0	0	0	0
			6					
			7	0	0	0	0	0
			8					
	at 325 psig nitrogen	cc/hr.	1	2.5	0	2.0	0	0
			2			0		
			3	0	0	0	0	0*
			4					0
			5	4.0	0	0	0	0
			6					
			7	1.0	0	0	0	0
			8					
	Dry Cycles			100 ~	100 ~	100 ~	100 ~	100 ~
	at 50 psig nitrogen	cc/hr.	1	1.5	0	0	0	0
			2			3.0		
			3	2.5	0	0	0	0*
			4					0
			5	3.5	0	0	0	0
			6					
			7	3.0	0	0	0	0
			8					
	at 325 psig nitrogen	cc/hr.	1	2.5	0	0	0	0
			2				1.0	1.0
			3	0	0	0	1.0	0*
			4				0	0
			5	1.5	0	0	0	0
			6					
			7	0	0	0	0	0
			8					

** Pressurized with 325 psig nitrogen and immersed in freon

QUALIFICATION TEST
Model 50-304
Serial Number 126

			Acceptance Test Data as Prototype A.T.P.	Post Phase I of Life (10,000 ~)	Post Phase II of Life (20,000 ~)	Post Phase III of Life (30,000 ~)	Post Phase IV of Life (39,881 ~)
* Broken Flexure Sleeve	Date		4/14/67	5/4/67	5/6/67	5/8/67	5/9/67
	Limits	Coil					
Reverse Seat Leakage at 20 psig nitrogen	cc/hr.	1	0	0	0	0	6.0
		2					0
		3	3.0	0	0	0	2.0*
		4					0
		5	0	0	0	0	4.0
		6					0
		7	6.0	0	0	0	0
		8					

QUALIFICATION TEST
Model 50-304
Serial Number 127

		Limits	Coil	Acceptance Test Data as/Prototype A.T.P.	Post Handling Shock	Post Phase I of Life (10,000...)	Post Phase II of Life (20,000...)	Post Phase III of Life (30,000...)	Post Phase IV of Life (40,000...)	Final Performance as/A.T.P.
		Date		4/10/67	5/3/67	5/5/67	5/6/67	5/8/67	5/9/67	5/15/67
Examination of Product	Visual Inspect			ok	—	—	—	—	—	—
	Weight			8.44 lbs.	—	—	—	—	—	—
Proof Pressure	Valve Assembly			ok	—	—	—	—	—	ok
	Seat Assembly			ok	—	—	—	—	—	ok
Electrical Resistance	Coil Resistance		DF_1	22.2	22.28	—	—	—	—	22.21
			LN_2	22.2	22.32	—	—	—	—	22.23
			UW_3	22.1	22.30	—	—	—	—	21.13
			ZP_4	22.2	22.30	—	—	—	—	22.24
			AC_5	22.2	22.33	—	—	—	—	22.24
			HK_6	22.1	22.20	—	—	—	—	22.13
			RT_7	22.2	22.33	—	—	—	—	22.25
			GY_8	22.2	22.25	—	—	—	—	22.21
Insulation Resistance	Each Coil to Valve Body		DF_1	4500	—	—	—	—	—	20,000
			LN_2	4300	—	—	—	—	—	15,000
			UW_3	5500	—	—	—	—	—	14,000
			ZP_4	5000	—	—	—	—	—	14,000
			AC_5	6000	—	—	—	—	—	15,000
			HK_6	5000	—	—	—	—	—	12,000
			RT_7	6100	—	—	—	—	—	13,000
			GY_8	6100	—	—	—	—	—	10,000
	Each Coil to all Other Coils		DF_1	6800	—	—	—	—	—	8,500
			LN_2	5900	—	—	—	—	—	7,000
			UW_3	7500	—	—	—	—	—	8,500
			ZP_4	6400	—	—	—	—	—	8,500
			AC_5	7200	—	—	—	—	—	8,000
			HK_6	6300	—	—	—	—	—	7,200
			RT_7	7200	—	—	—	—	—	8,000
			GY_8	6200	—	—	—	—	—	6,500
Dielectric Strength	All Coils to Case			34 μa	—	—	—	—	—	2.0 μa
	All Coils to Conn.			<1.0 μa	—	—	—	—	—	5.0 μa

QUALIFICATION TEST
Model 50-304
Serial Number 127

				Acceptance Test Data as/Prototype A.T.P.		Post Handling Shock		Post Phase I of Life (10,000)		Post Phase II of Life (20,000)		Post Phase III of Life (30,000)		Post Phase IV of Life (40,000)		Final Performance as/A.T.P.	
		Date		4/10/67		5/3/67		5/5/67		5/6/67		5/8/67		5/9/67			
		Limits	Coil	On	Off	On	Off	On	Off	On	Off	On	Off	On	Off	On	Off
Response Test	Condition (a)		1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			3	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			4	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			5	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			6	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			7	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			8	–	–	–	–	–	–	–	–	–	–	–	–	–	–
			1	4.5	8.5	6.0	9.5	5.5	9.5	8.0	8.0	8.0	8.5	6.0	8.5	5.5	8.5
	Condition (b)		2	5.0	9.0	5.5	9.5	5.5	10.0	9.0	9.0	10.0	7.5	9.0	7.5	9.8	9.8
	All motors		3	9.0	5.0	11.5	7.0	8.0	6.5	7.5	5.5	10.0	6.5	8.0	6.0	9.0	6.0
	operating		4	4.5	6.0	11.0	6.5	8.5	7.0	6.5	6.5	6.0	7.0	6.0	7.5	5.0	7.0
			5	8.0	5.5	10.5	6.0	9.5	6.5	9.0	6.0	10.0	6.5	10.0	6.0	8.0	6.5
			6	9.0	9.5	6.0	10.0	5.0	10.0	6.5	9.5	9.0	10.0	9.0	10.0	5.0	10.0
			7	4.5	9.0	4.5	9.0	4.5	9.0	4.5	8.0	4.8	9.0	4.5	8.5	4.5	8.0
			8	6.0	7.0	10.5	7.0	10.0	7.0	10.0	7.0	11.0	7.5	10.5	7.0	9.5	7.0
Flow Test	Both Series	F		9.4 psig		8.7 psig		9.0 psig		8.7 psig		9.0 psig		9.3 psig		9.3 psig	
	Legs Flowing	O		11.7 psig		11.3 psig		11.5 psig		11.4 psig		11.6 psig		11.5 psig		12.1 psig	
	One Series Leg	F		23.5 psig		–		–		–		–		–		24.2 psig	
	Open 1&3, 5&7	O		33.6 psig												32.9 psig	
	One Series Leg	F		25.0 psig		–		–		–		–		–		24.8 psig	
	Open 2&4, 6&8	O		32.5 psig												32.0 psig	
Functional Test	Pull-In Voltage	Volts/	1	13.5	–	12.1	.515	–		–		–		–		14.2	–
	at 325 psig	Amps	2	13.7	–	11.9	.501	–		–		–		–		14.5	–
			3	16.4	–	10.8	.465	–		–		–		–		13.8	–
			4	14.4	–	11.0	.471	–		–		–		–		11.6	–
			5	15.5	–	12.1	.515	–		–		–		–		15.5	–
			6	13.3	–	11.9	.501	–		–		–		–		14.3	–
			7	13.7	–	10.8	.465	–		–		–		–		11.1	–
			8	14.0	–	11.0	.471	–		–		–		–		13.5	–

QUALIFICATION TEST
Model 50-304
Serial Number 127

			Acceptance Test Data as/Prototype A.T.P.		Post Handling Shock		Post Phase I of Life (10,000~)		Post Phase II of Life (20,000~)		Post Phase III of Life (30,000~)		Post Phase IV of Life (40,000~)		Final Performance as/A.T.P.	
	Date		4/10/67		5/3/67		5/5/67		5/6/67		5/8/67		5/9/67			
	Limits	Coil	Volts	Amps	Volts	Amps	Volts	Amps	Volts	Amps	Volts	Amps	Volts	Amps	Volts	Amps
Functional Test Pull-In Voltage at 325 psig		1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Drop Out Voltage at 166 psig (Condition a)		1	—	—	2.10	.084	—	—	—	—	—	—	—	—	—	—
		2	—	—	1.40	.059	—	—	—	—	—	—	—	—	—	—
		3	—	—	2.37	.101	—	—	—	—	—	—	—	—	—	—
		4	—	—	1.48	.061	—	—	—	—	—	—	—	—	—	—
		5	—	—	2.10	.084	—	—	—	—	—	—	—	—	—	—
		6	—	—	1.40	.059	—	—	—	—	—	—	—	—	—	—
		7	—	—	1.91	.082	—	—	—	—	—	—	—	—	—	—
		8	—	—	1.48	.061	—	—	—	—	—	—	—	—	—	—
Drop Out Voltage at 166 psig (Condition b)		1	Does	Not	—	—	—	—	—	—	—	—	—	—	Does	Not
		2	Does	Not	—	—	—	—	—	—	—	—	—	—	Does	Not
		3	.7	—	—	—	—	—	—	—	—	—	—	—	Does	Not
		4	Does	Not	—	—	—	—	—	—	—	—	—	—	Does	Not
		5	Does	Not	—	—	—	—	—	—	—	—	—	—	Does	Not
		6	Does	Not	—	—	—	—	—	—	—	—	—	—	Does	Not
		7	Does	Not	—	—	—	—	—	—	—	—	—	—	Does	Not
		8	Does	Not	—	—	—	—	—	—	—	—	—	—	Does	Not
Drop Out Voltage at 5 psig nitrogen	Volts/ Amps	1	2.3	—	—	—	—	—	—	—	—	—	—	—	2.73	—
		2	2.0	—	—	—	—	—	—	—	—	—	—	—	2.44	—
		3	3.0	—	—	—	—	—	—	—	—	—	—	—	2.93	—
		4	2.2	—	—	—	—	—	—	—	—	—	—	—	2.20	—
		5	2.9	—	—	—	—	—	—	—	—	—	—	—	2.81	—
		6	1.7	—	—	—	—	—	—	—	—	—	—	—	1.12	—
		7	2.0	—	—	—	—	—	—	—	—	—	—	—	2.08	—
		8	1.9	—	—	—	—	—	—	—	—	—	—	—	2.24	—

QUALIFICATION TEST
Model 50-304
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* Broken Flexure Sleeve		Date		Acceptance Test Data as/Prototype A.T.P.	Post Handling Shock	Post Phase I of Life (10,000 c)	Post Phase II of Life (20,000 c)	Post Phase III of Life (30,000 c)	Post Phase IV of Life (40,000 c)	Final Performance as/A.T.P.
				4/10/67	5/3/67	5/5/67	5/6/67	5/8/67	5/9/67	
		Limits Coil								
External Leakage	Helium Gas	Fuel		4.25×10^{-7}	3.08×10^{-6}	**None	**None	**None	**None	1.78×10^{-6}
at 325 psig		Oxidizer		3.49×10^{-7}	3.34×10^{-6}	**None	**None	**None	**None	1.67×10^{-6}
Internal Leakage	at 50 psig nitrogen	cc/hr.	1	3.0	0	0	0	0	0	0
			2							
			3	0	0	0	0	0	0	0
			4					2.0		
			5	0	0	0	0	0	0	0
			6							
			7	0	0	0	0	0	0	0
			8							
	at 325 psig nitrogen	cc/hr.	1	0	0	0	0	0	0	0
			2							
			3	0	0	0	0	0	0	0
			4							
			5	0	0	0	0	0	0	0
			6							
			7	0	0	0	0	0	0	0
			8							
	Dry Cycles			100 ~	100 ~	100 ~	100 ~	100 ~	100 ~	100 ~
	at 50 psig nitrogen	cc/hr.	1	0	0	0	0	0	0	0
			2							
			3	0	0	0	0	1.0	0	0
			4					2.0		
			5	0	0	0	0	0	0	0
			6							
			7	0	0	0	0	0	0	0
			8							
	at 325 psig nitrogen	cc/hr.	1	1.2	0	0	0	0	0	0
			2							
			3	1.2	0	0	1.0	0	0	0
			4				0	1.0		
			5	0	0	0	0	0	0	.0
			6							
			7	0	0	0	0	0	0	0
			8							

** Pressurized with 325 psig nitrogen and immersed in freon

QUALIFICATION TEST
Model 50-304
Serial Number 127

* Broken Flexure Sleeve

				Acceptance Test Data as/Prototype A.T.P.	Post Handling Shock	Post Phase I of Life (10,000)	Post Phase II of Life (20,000)	Post Phase III of Life (30,000)	Post Phase IV of Life (40,000)	Final Performance as/A.T.P.
		Date		4/10/67	5/3/67	5/5/67	5/6/67	5/8/67	5/9/67	
		Limits	Coil							
Reverse Seat Leakage	at 20 psig	cc/hr.	1	0	7.0	4.0	1.0	0	6.6	0
			2		1.0	0	0	4.2	0	
			3	0	3.0	3.0	0	0	3.6	0
	nitrogen		4		0	0	19.2	6.0	12.9	
			5	0	6.0	3.0	0	0	10.8	2.0
			6		0	1.0		5.0	0	
			7	0	0	0	0	0	3.6	0
			8					6.0	0	

QUALIFICATION TEST
Model 50-304
Serial Number 129

			Acceptance Test Data as/Prototype A.T.P.	Pre +180° F Temperature Test	+180° F Temperature Test	Post +180° F Temperature Test	Pre +12° F Temperature Test	+12° F Temperature Test	Post +12° F Temperature Test				
		Date	5/10/67	5/11/67	5/11/67	5/11/67	5/12/67	5/12/67	5/15/67				
		Limits Coil											
Examination of Product	Visual Inspect		ok	—	—	—	—	—	—				
	Weight		8.07 lbs	—	—	—	—	—	—				
Proof Pressure	Valve Assembly		ok	—	—	—	—	—	—				
	Seat Assembly		ok	—	—	—	—	—	—				
Electrical Resistance	Coil Resistance	DF_1	22.3	—	—	22.57	—	—	22.34				
		LN_2	22.2	—	—	22.75	—	—	22.32				
		UW_3	21.9	—	—	22.21	—	—	22.03				
		ZP_4	22.0	—	—	22.40	—	—	22.13				
		AC_5	22.0	—	—	22.32	—	—	22.19				
		HK_6	22.2	—	—	22.56	—	—	22.31				
		RT_7	22.1	—	—	22.35	—	—	22.25				
		GY_8	22.0	—	—	22.32	—	—	22.17				
Insulation Resistance	Each Coil to Valve Body	DF_1	4500	—	—	—	—	—	—				
		LN_2	6000										
		UW_3	9000	—	—	—	—	—	—				
		ZP_4	9000										
		AC_5	12000	—	—	—	—	—	—				
		HK_6	14000										
		RT_7	18000	—	—	—	—	—	—				
		GY_8	15000										
	Each Coil to all Other Coils	DF_1	11000	—	—	—	—	—	—				
		LN_2	11000										
		UW_3	17000	—	—	—	—	—	—				
		ZP_4	11000										
		AC_5	12000	—	—	—	—	—	—				
		HK_6	12000										
		RT_7	15000	—	—	—	—	—	—				
		GY_8	10000										
Dielectric Strength	All Coils to Case		42μa	—	—	—	—	—	—				
	All Coils to Conn.		1μa										

QUALIFICATION TEST
Model 50-304
Serial Number 129

				Acceptance Test Data Prototype as/A.T.P.		Pre +180° F Temperature Test		+180° F Temperature Test		Post +180° F Temperature Test		Pre +12° F Temperature Test		+12° F Temperature Test		Post +12° F Temperature Test	
		Date		5/10/67		5/11/67		5/11/67		5/11/67		5/12/67		5/12/67		5/15/67	
		Limits	Coil														
Response			1	—		—		—		—		—		—		—	
			2	—		—		—		—		—		—		—	
			3	—		—		—		—		—		—		—	
			4	—		—		—		—		—		—		—	
			5	—		—		—		—		—		—		—	
			6	—		—		—		—		—		—		—	
			7	—		—		—		—		—		—		—	
			8	—		—		—		—		—		—		—	
	Condition (b) All Motors Operating		1	5.0	10.5	5.5	8.0	8.0	7.0	4.5	8.0	9.0	8.0	6.5	9.0	5.0	7.5
			2	5.5	10.5	5.0	12.0	6.5	9.5	4.5	10.5	5.5	11.0	4.0	12.5	5.0	11.0
			3	8.5	7.0	7.5	7.5	8.0	6.0	5.0	7.0	8.5	7.5	5.0	8.0	9.0	7.0
			4	8.5	7.5	8.0	7.5	8.0	6.0	5.0	7.0	9.0	7.5	6.5	8.0	9.0	7.5
			5	8.0	7.5	8.0	7.5	7.5	6.5	7.5	7.0	8.5	7.5	6.5	8.5	7.5	7.0
			6	8.0	7.5	5.0	8.0	6.5	7.5	4.5	9.0	5.0	9.0	4.5	11.0	8.0	9.0
			7	5.0	9.5	5.0	8.5	4.5	7.5	5.0	8.0	5.0	8.5	5.0	10.0	5.0	7.0
			8	8.0	7.5	8.0	7.5	7.0	6.5	8.5	7.0	8.5	8.0	6.5	8.0	5.0	8.5
Flow Test	Both Series Legs Flowing	F		10.2 psig		—		—		9.9 psig		—		—		9.8 psig	
		O		13.7 psig						13.3 psig						13.2 psig	
	One Series Leg Open 1&3, 5&7			27.2 psig		—		—		—		—		—		—	
				37.7 psig													
	One Series Leg Open 2&4, 6&8			26.3 psig		—		—		—		—		—		—	
				35.9 psig													
Functional Test	Pull-In Voltage at 325 psig	Volts/ Amps	1	13.2		Applied 20 vdc at 325 psig	and cycled 10 times	Applied 20 vdc at 325 psig	and cycled 10 times	12.1	.481	Applied 20 vdc at 325 psig	and cycled 10 times	Applied 20 vdc at 325 psig	and cycled 10 times	10.7	.471
			2	14.2						12.1	.485					10.6	.470
			3	12.8						11.5	.461					10.9	.464
			4	13.5						11.5	.464					10.4	.457
			5	15.3						12.1	.461					10.7	.471
			6	15.0						12.1	.485					10.6	.470
			7	13.6						11.5	.461					10.5	.464
			8	12.7						11.5	.464					10.4	.457

QUALIFICATION TEST
Model 50-304
Serial Number 129

				Acceptance Test Data as/Prototype A.T.P.		Pre +180° F Temperature Test		+180° F Temperature Test		Post +180° F Temperature Test		Pre +12° F Temperature Test		+12° F Temperature Test		Post +12° F Temperature Test	
		Date		5/10/67		5/11/67		5/11/67		5/11/67		5/12/67		5/12/67		5/15/67	
		Limits	Coil	Volts	Amps	Volts	Amps	Volts	Amps	Volts	Amps	Volts	Amps	Volts	Amps	Volts	Amps
Functional Test	Pull-in Voltage at 325 psig (Condition b)		1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			6	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
			8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Drop Out Voltage at 166 psig (Condition a)		1	—	—	—	—	—	—	1.48	.062	—	—	—	—	1.43	.064
			2	—	—	—	—	—	—	1.25	.054	—	—	—	—	1.16	.049
			3	—	—	—	—	—	—	1.51	.066	—	—	—	—	1.61	.070
			4	—	—	—	—	—	—	1.55	.066	—	—	—	—	1.50	.065
			5	—	—	—	—	—	—	1.48	.062	—	—	—	—	1.43	.064
			6	—	—	—	—	—	—	1.25	.054	—	—	—	—	1.16	.049
			7	—	—	—	—	—	—	1.51	.066	—	—	—	—	1.61	.070
			8	—	—	—	—	—	—	1.55	.066	—	—	—	—	1.50	.065
	Drop Out Voltage at 166 psig (Condition b)		1	Does	Not	—	—	—	—	—	—	—	—	—	—	—	—
			2	Does	Not	—	—	—	—	—	—	—	—	—	—	—	—
			3	1.2	.04	—	—	—	—	—	—	—	—	—	—	—	—
			4	0.6	.022	—	—	—	—	—	—	—	—	—	—	—	—
			5	.3	.01	—	—	—	—	—	—	—	—	—	—	—	—
			6	0.7	.02	—	—	—	—	—	—	—	—	—	—	—	—
			7	Does	Not	—	—	—	—	—	—	—	—	—	—	—	—
			8	Does	Not	—	—	—	—	—	—	—	—	—	—	—	—
	Drop Out Voltage at 5 psig nitrogen (Condition c)	Volts/ Amps	1	1.7		—	—	—	—	—	—	—	—	—	—	—	—
			2	1.8		—	—	—	—	—	—	—	—	—	—	—	—
			3	1.7		—	—	—	—	—	—	—	—	—	—	—	—
			4	1.85		—	—	—	—	—	—	—	—	—	—	—	—
			5	1.75		—	—	—	—	—	—	—	—	—	—	—	—
			6	1.7		—	—	—	—	—	—	—	—	—	—	—	—
			7	1.6		—	—	—	—	—	—	—	—	—	—	—	—
			8	1.95		—	—	—	—	—	—	—	—	—	—	—	—

QUALIFICATION TEST
Model 50-304
Serial Number 129

* Broken Flexure Sleeve

				Acceptance Test Data as/Prototype A.T.P.	Pre +180° F Temperature Test	+180° F Temperature Test	Post +180° F Temperature Test	Pre +12° F Temperature Test	+12° F Temperature Test	Post +12° F Temperature Test				
		Date		5/10/67	5/11/67	5/11/67	5/11/67	5/12/67	5/12/67	5/15/67				
External Leakage	Helium Gas	Limits Fuel	Coil	3.6×10^{-6}	—	—	**None	—	**None	2.48×10^{-7}				
at 325 psig		Oxidizer		3.6×10^{-6}	—	—	**None	—	**None	2.91×10^{-7}				
Internal Leakage	at 50 psig nitrogen	cc/hr.	1	4.0	—	0	0	—	0	0				
			2											
			3	0	—	0	0	—	0	0				
			4											
			5	4.25	—	0	0	—	0	0				
			6											
			7	0	—	0	0	—	0	0				
			8											
	at 325 psig nitrogen	cc/hr.	1	3.5	—	0	0	—	0	0				
			2											
			3	0	—	0	0	—	0	0 1.0				
			4											
			5	4.5	—	0	0	—	0	0				
			6											
			7	0	—	0	0	—	0	0				
			8											
	Dry Cycles			100 ~	—	100 ~	100 ~	—	100 ~	100 ~				
	at 50 psig nitrogen	cc/hr.	1	2.5	—	0	0	—	0	0				
			2											
			3	0	—	0	0	—	0	0				
			4											
			5	2.5	—	0	0	—	0	0				
			6											
			7	0	—	0	0	—	0	0				
			8											
	at 325 psig nitrogen	cc/hr.	1	2.5	—	0	0	—	0	0				
			2											
			3	0	—	0	0	—	0	0				
			4											
			5	2.5	—	0	0 1.0	—	0	.0				
			6											
			7	0	—	0	0	—	0	0				
			8											

** Pressurized with 325 psig nitrogen and immersed in freon

QUALIFICATION TEST
Model 50-304
Serial Number 129

* Broken Flexure Sleeve

		Limits	Coil	Acceptance Test Data as/Prototype A.T.P.	Pre +180° F Temperature Test	+180° F Temperature Test	Post +180° F Temperature Test	Pre +12° F Temperature Test	+12° F Temperature Test	Post +12° F Temperature Test
		Date		5/10/67	5/11/67	5/11/67	5/11/67	5/12/67	5/12/67	5/15/67
Reverse Seat Leakage	at 20 psig	cc/hr.	1	0	—	—		—		6.0
			2							0
			3	0	—	—	0	—	—	3.0
	nitrogen		4							0
			5	0	—	—	0	—	—	5.0
			6							0
			7	0	—	—	0	—	—	1.0
			8							0

QUALIFICATION TEST
Model No. 50-304
Serial No. 130

Acceptance Test Data

Test			Results
1. Examination of product	Valve assembly		ok
	Weight		8.07
2. Proof pressure	Valve assembly		ok
	Seat assembly		ok
3. Electrical resistance	Coil resistance		
		1	22.9
		2	22.6
		3	22.3
		4	22.2
		5	22.7
		6	22.5
		7	22.2
		8	22.3
4. Insulation resistance	Each coil to valve body		
		1	9,000
		2	10,000
		3	9,000
		4	17,000
		5	10,000
		6	18,000
		7	18,000
		8	19,000
	Each coil to all other coils	1	17,000
		2	15,000
		3	15,000
		4	14,000
		5	13,000
		6	14,000
		7	13,000
		8	11,000

Test			Results	
5.	Response	Condition b	on	off
		1	5.5	7.5
		2	5.5	9
		3	9.5	5
		4	5	6.5
		5	9	7
		6	8.5	7.5
		7	9	8
		8	4	9
6.	Functional Test	Pull-in voltage at 325 psig, condition a		
		1	15.8	
		2	15.3	
		3	13.1	
		4	12.9	
		5	14.0	
		6	13.9	
		7	12.7	
		8	13.4	
		Drop-out voltage at 5 psig, condition c		
		1	2.3	
		2	2.1	
		3	2.9	
		4	2.0	
		5	1.4	
		6	1.1	
		7	1.6	
		8	1.4	
7.	Flow Test	Both series legs flowing	9.4	
			12.0	
		One series leg open, 1&3, 5&7	25.4	
			34.2	
		One series leg open, 2&4, 6&8	25.8	
			34.3	
8.	External Leakage	at 325 psig Fuel	3.03×10^{-6}	
		Oxidizer	3.3×10^{-6}	

Test			Results
9. Internal Leakage	at 50 psig	1	-
		2	-
		3	-
		4	-
		5	-
		6	-
		7	-
		8	-
	at 325 psig	1	4.25
		2	
		3	-
		4	-
		5	-
		6	-
		7	-
		8	-
	100 cycles at 50 psig	1	2.5
		2	
		3	-
		4	-
		5	-
		6	-
		7	-
		8	-
	at 325 psig	1	-
		2	-
		3	-
		4	-
		5	-
		6	-
		7	-
		8	-

9.0 TEST EQUIPMENT

The test equipment that was used for the Qualification Test Program has been identified and described in the following test equipment list.

TEST EQUIPMENT

Nomenclature	Part No. / Manufacturer	Range, Accuracy	Cal. Period
Function Generator	Hewlett Packard Mod. 202A	Range: 0.01 to 1200 cps Accuracy: ±2%	6 mo.
Oscilloscope Record Camera	Dumont Type 297	Range: N.A. Accuracy: N.A.	N.A.
Thermal Vacuum Chamber	General Vacuum Corporation Mod. 4	---	---
Altitude Recorder	General Vacuum Corporation Mod. G1C - 100	---	6 mo.
Temperature Controller	Minneapolis Honeywell Pyp-o-Vane	Accuracy: ±10.5 F	3 mo.
Hi Pot.	Spellman	Accuracy: ±2%	3 mo.
Meter	Simpson Mod. 260	Accuracy: ±2%	3 mo.
High Temperature Hydraulic Supply	Denison Mod. PA-202-576	Range: 0 to 5000 psi 20 cpm	N.A.
Low Temperature Hydraulic Supply	Moog Inc.	Range: 0 to 4000 psi	N.A.

TEST EQUIPMENT

Nomenclature	Part No. /Manufacturer	Range, Accuracy	Cal. Period
Kelvin Wheatstone	Shallcross Mfg. Mod. 638R, S/N 28267	Range - 0.00/ohm to 9999 megohms accuracy ±0.1%	3 mo.
Vibrotester	Associated Research Mod. 224A, S/N 224A68	Range: 0 to 100 megohms o to 1000 megohms	6 mo.
Leakage Tester	Slaughter Co. Mod. 103-2.5J S/N Z-103075	Range: 0 to 2500 vac Range- meter 0 to 100 a 0 to 1000 a 0 to 5000 a Accuracy ±3% full scale	6 mo.
Leakage Detector	CEC Model 24-120B	Range: N.A. Accuracy: N.A.	At use
Test Console	Moog Inc. Model 40-160	Range Current 0 to 2 amps Voltage 0 to 33 volts Accuracy ±1% F.S.	3 mo.
Oscilloscope	Tektronix Type 502	Time Base Range 1 sec/cm Accuracy: ±5% F.S.	2 mo.
		Voltage Range 200 v/cm to 20 v/cm; Accuracy ±3% F.S.	2 mo.
D.C. Voltmeter	United Systems Corp. Mod. 201 DC	Range: 0 to 1000 Accuracy: ±0.1% F.S.	6 mo.

TEST EQUIPMENT

Nomenclature	Part No. / Manufacturer	Range, Accuracy	Cal. Period
Water System	**Moog**	Gauges:	
		Manufacturer / Range / Accuracy	5 mo.
		U.S. Gauge 0-1000 ±0.5%	
		0-5000	
		Helicoid 0-600 ±0.25%	
		Midwest 0-50 ±0.5%	
		2 Counter Cox Mod. 850 ak	3 mo.
		Accuracy: ±1 count	

Thiokol
REACTION MOTORS DIVISION

APPENDIX M

ENVIRONMENTAL TEST REPORT

GPI REPORT E 1256

GPL DIVISION

GENERAL PRECISION INC.

AEROSPACE GROUP

ENVIRONMENTAL TEST REPORT

NO. E-1256

ITEM DESCRIPTION

QUADREDUNDANT VALVE S/N 128

MANUFACTURED BY Thiokol Chemical Reaction Motors Division

MFRS PART NO. 317013 GPL PART NO. ---

QUANTITY 1 Unit CHARGE NO. _____

TEST REQUESTEE V. Banco

TEST CONDUCTED BY J. C. Smith

TEST REPORT BY K. Molnar

APPROVED BY _____ DATE 5 June 1967

D. G. Gray, Section Manager
Electromagnetic Compatibility Section

GPL-318

TABLE OF CONTENTS

1. PURPOSE

1.1 TO DETERMINE WHETHER OR NOT THE QUADREDUNDANT VALVE, HEREAFTER REFERRED TO AS THE TEST SPECIMEN, MEETS THE REQUIREMENTS OF MIL-I-6181D FOR RADIO FREQUENCY INTERFERENCE AND SUSCEPTIBILITY.

2. DOCUMENTATION

2.1 GPL TEST REQUEST NO. E-1256 DATED 5/24/67.

2.2 CUSTOMER'S PURCHASE ORDER NO. C-25276 DATED 5/23/67.

2.3 INTERFERENCE CONTROL REQUIREMENTS, AIRCRAFT EQUIPMENT, MIL-I-6181D, DATED 25 NOVEMBER 1959.

2.4 PROPELLANT VALVE ELECTRICAL INTERFERENCE TEST SPECIFICATION #1426.

3. TEST EQUIPMENT

3.1 EACH OF THE ITEMS LISTED BELOW FOR WHICH A DATE IS ENTERED IN THE "CAL. DUE" COLUMN IS PERIODICALLY CALIBRATED. THESE ITEMS ARE CALIBRATED WITH SECONDARY STANDARDS WHICH ARE IN TURN CALIBRATED WITH PRIMARY STANDARDS. THE CALIBRATION OF THE PRIMARY STANDARDS IS DIRECTLY TRACEABLE TO THE UNITED STATES BUREAU OF STANDARDS.

3.2 THE ITEMS FOR WHICH "EXEMPT" IS ENTERED IN THE "CAL. DUE" COLUMN DO NOT REQUIRE CALIBRATION.

3.3 ITEMS USED FOR RADIO INTERFERENCE TESTING.

ITEM DESCRIPTION	MFR.	MODEL	GPL NO.	CAL.DUE
FIELD INTENSITY METER	EMPIRE	NF-105	Z-164	9-18-67
TUNING UNIT	EMPIRE	T-A/NF-105	C-3818	9-18-67
TUNING UNIT	EMPIRE	T-1/NF-105	ET-169-2	9-18-67
TUNING UNIT	EMPIRE	T-2/NF-105	ET-169-3	9-18-67

3.3 CONTINUED -

ITEM DESCRIPTION	MFR.	MODEL	GPL NO.	CAL.DUE
TUNING UNIT	EMPIRE	T-3/NF-105	S/N 2329	9-18-67
FIELD INTENSITY METER	POLARAD	FIM	C-2729	8-24-67
RF TUNING UNIT	POLARAD	FIM-L	C-2729-2	8-24-67
RF TUNING UNIT	POLARAD	FIM-S	C-2729-3	8-24-67
RF TUNING UNIT	POLARAD	FIM-M	C-2729-4	8-24-67
RF TUNING UNIT	POLARAD	FIM-X	C-2729-5	8-24-67
41" ROD ANTENNA	EMPIRE	VA-105	----	EXEMPT
DIPOLE ANTENNAS	EMPIRE	DM-105-T1,T2,T3	----	EXEMPT
DIRECTIVE ANTENNA	POLARAD	CA-L	C-2729-7	EXEMPT
DIRECTIVE ANTENNA	POLARAD	CA-S	C-2729-8	EXEMPT
DIRECTIVE ANTENNA	POLARAD	CA-M	C-2729-9	EXEMPT
DIRECTIVE ANTENNA	POLARAD	CA-X	C-2729-10	EXEMPT
SWITCHING UNIT	EMPIRE	SU-105	----	EXEMPT
LINE STABILIZATION NETWORKS (LISN'S)	FILTRON	FSR-701AC	----	EXEMPT
50 OHM LOADS	NARDA	370NM	----	EXEMPT
TRIPOD	STODDART	90310-1	----	EXEMPT
SHIELDED ENCLOSURE	SHIELDING, INC.	T-1085	----	EXEMPT

3.4 ADDITIONAL ITEMS USED FOR SUSCEPTIBILITY TESTING.

ITEM DESCRIPTION	MFR.	MODEL	GPL NO.	CAL.DUE
RF CURRENT PROBE	EMPIRE	MX-936/URM	----	EXEMPT
SIGNAL GENERATOR	HP	606A	C-3282	9-18-67
VHF SIGNAL GENERATOR	HP	608B	ET-2955	9-18-67
SIGNAL GENERATOR	HP	612A	ET-239	9-18-67
ROD ANTENNA & COUNTERPOISE	GPL	SK31769-758	----	EXEMPT

4. TEST PROCEDURE

4.1 INITIAL TEST SETUP

THE TEST SPECIMEN WAS INSTALLED ON THE COPPER GROUND PLANE IN THE SHIELDED ENCLOSURE AS SHOWN IN FIGURE 1. LINE IMPEDANCE STABILIZATION NETWORKS WERE INSERTED IN THE FOLLOWING LINES OF THE TEST SPECIMEN.

a) + 22 VOLTS D.C.

b) - 22 VOLTS D.C.

THE TEST SPECIMEN WAS OPERATED IN EACH OF THE FOLLOWING MODES DURING INTERFERENCE AND SUSCEPTIBILITY TESTING:

a) 500 SEC. ON-DURING INTERFERENCE TESTING

b) 50 MILISEC. ON-50 MILISECONDS OFF-CYCLING, INTERFERENCE AND SUSCEPTIBILITY TESTING.

ALL UNITS, INCLUDING THE LINE IMPEDANCE STABILIZATION NETWORKS, WERE RIGIDLY SECURED TO THE GROUND PLANE BY MEANS OF BRASS BONDING STRAPS.

4.2 RADIATED RADIO FREQUENCY INTERFERENCE TEST

THE TEST SPECIMEN WAS SUBJECTED TO A RADIATED RADIO FREQUENCY INTERFERENCE TEST OVER THE FREQUENCY RANGE OF 150KC TO 10GC IN ACCORDANCE WITH PARAGRAPH 4.3.2 OF MIL-I-6181D. THE TEST SPECIMEN WAS OPERATED AS DESCRIBED IN PARAGRAPH 4.1 OF THIS REPORT DURING RADIATED INTERFERENCE TESTING.

RE: RADIATED RADIO FREQUENCY INTERFERENCE TEST DATA, APPENDIX I, PAGES 8

4.3 CONDUCTED RADIO FREQUENCY SUSCEPTIBILITY TEST

THE TEST SPECIMEN WAS SUBJECTED TO A CONDUCTED RADIO FREQUENCY SUSCEPTIBILITY TEST OVER THE FREQUENCY RANGE OF 150KC TO 10GC IN ACCORDANCE WITH PARAGRAPH 4.3.4.1.1 OF MIL-I-6181D. THE TEST SPECIMEN WAS MONITORED DURING THIS TEST FOR ANY CHANGE IN INDICATION, MALFUNCTIONING, OR DEGRADATION OF PERFORMANCE.

RE: CONDUCTED RADIO FREQUENCY SUSCEPTIBILITY TEST DATA, APPENDIX II, PAGES 10

4.4 RADIATED RADIO FREQUENCY SUSCEPTIBILITY TEST

THE TEST SPECIMEN WAS SUBJECTED TO A RADIATED RADIO FREQUENCY SUSCEPTIBILITY TEST OVER THE FREQUENCY OF 150KC TO 1GC IN ACCORDANCE WITH PARAGRAPH 4.3.4.3 OF MIL-I-6181D. THE TEST SPECIMEN WAS MONITORED DURING THIS TEST FOR ANY CHANGE IN INDICATION, MALFUNCTIONING, OR DEGRADATION OF PERFORMANCE.

RE: RADIATED RADIO FREQUENCY SUSCEPTIBILITY TEST DATA, APPENDIX III, PAGE 12

5. TEST RESULTS

TEST	RESULTS	DATA PAGES	REMARKS
RADIATED INTERFERENCE	REQUIREMENTS MET	8	N/C
CONDUCTED RF SUSCEPTIBILITY	REQUIREMENTS MET	10	N/C
RADIATED RF SUSCEPTIBILITY	REQUIREMENTS MET	12	N/C

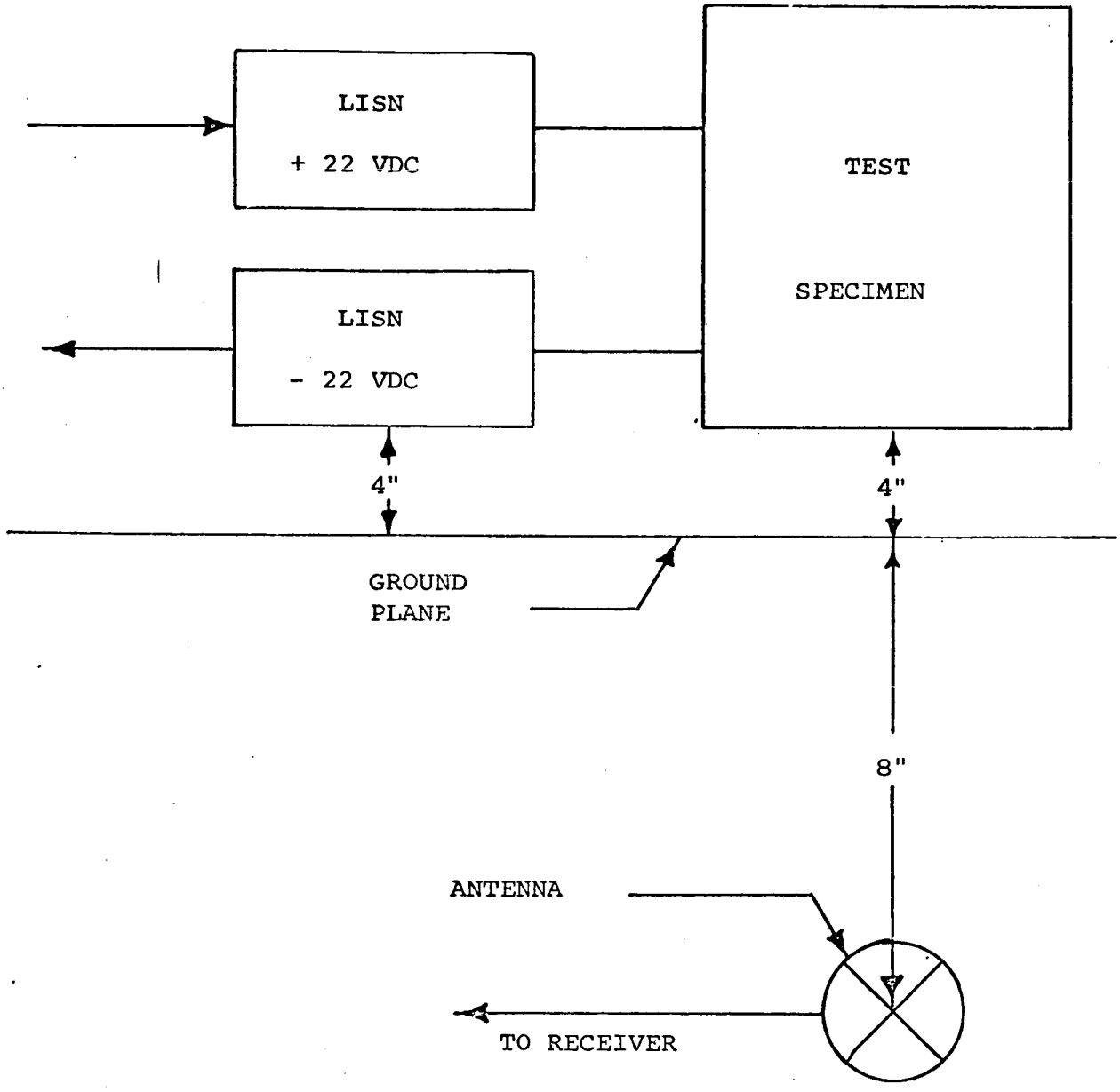

FIGURE 1. TEST SETUP FOR THE QUADREDUNDANT VALVE

TEST REPORT SIGNATURES

THE DATA CONTAINED IN THIS REPORT WAS OBTAINED

BY TEST IN COMPLIANCE WITH THE APPLICABLE

TEST SPECIFICATION AS NOTED IN SECTION 2, DOCUMENTATION.

David G. Gray

DAVID G. GRAY, EMC SECTION
SPECIFICATION CONFORMANCE DEPARTMENT
GPL DIVIDION, GENERAL PRECISION AEROSPACE

M. Hamel

M. HAMEL, DCASR -- NY

APPENDIX I

RADIATED INTERFERENCE

RADIO FREQUENCY INTERFERENCE TEST DATA

Item Tested: QUAD REDUNDANT VALVE Ser. No: 128 Test No: E-1256

Type of Test: RADIATED Test Equipt. NF-105 Spec. No: MIL-I-6181D

Conducted By: JCL Date: 5-30-67 Checked By: [illegible] Para: 4.3.2

Operating Conditions: VALVE CYCLING 50MS ON 50MS OFF

Item Tested Line Voltage AC: —— DC: 22 VDC

Freq. (MC)	Spec. Limit DBuV/MC	Meter Reading DBUV/MC	Corr. Factor + DB	Final Reading DBUV/MC ANT. IND.	Type See Note B	Rec. Noise Level
.15	77.0	38	36.5	74.5	1	30
.20	75.4	35	35.8	70.8		
.30	73.0	32	36.0	68.0		
.40	71.3	30	29.5	59.5		
.60	69.8	30	31.0	61.0		
.80	69.5	30	32.0	62.0		
1.2	69.3	30	28.0	58.0		
1.6	68.7	30	27.8	57.8		
2.0	68.5	30	28.8	58.8		
2.4	68.4	30	23.3	53.3		
3.5	67.6	30	23.4	53.4		
5.0	67.6	30	23.5	53.5		
6.0	67.5	30	20.5	50.5		
9.0	67.0	30	16.5	46.5		
12	66.7	30	17.0	47.0		
15	66.5	30	14.1	44.1		
19	66.3	30	13.7	43.7		
25	66.0	30	14.4	44.4	↓	↓
25	44.0	30	8.3	38.3	1	30
35	48.4	30	8.5	38.5		
50	51.2	30	8.5	38.5		
70	52.4	30	8.7	38.7		
100	53.5	30	8.9	38.9		
140	54.5	30	9.3	39.3		
200	55.5	30	9.6	39.6		
280	56.7	30	10.1	40.1		
350	57.0	30	10.3	40.3		
400	57.7	30	10.5	40.5	↓	↓
↓		NO NARROWBAND	INTERFERENCE			
↓		IN THIS FREQUENCY	RANGE			
1GC		↓				

NOTE A - All Frequencies not listed are scanned for maximum interference

B - Inter. Type: 1. Broadband steady-state, rec. detector function "Peak"
2. Broadband, transients, rec. detector function "Peak"
3. Narrowband (CW), rec. detector function "Fl"

APPENDIX II

CONDUCTED R. F. SUSCEPTIBILITY

SUSCEPTIBILITY TEST DATA

ITEM TESTED: QUADREDUNDANT VALVE SER.NO. 128 TEST NO. E-1256

TYPE OF TEST: CONDUCTED SPEC. NO. MIL-I-6181D PARA: 4.3.4.1.1

CONDUCTED BY: JCL DATE: 5-30-67 CHECKED BY: OJT

ITEM TESTED LINE VOLTAGE: AC: —— DC: 22 VDC

FREQ.	LINE TESTED: +22VDC	LINE TESTED -22VDC
150 KC	NO INDICATION OF SUSCEPTIBILITY	NO INDICATION OF SUSCEPTIBILITY
↓	↓	↓
10 GC		

NOTE: 1.) All frequencies not listed are scanned for malfunction or degradation of performance.

APPENDIX III

RADIATED R. F. SUSCEPTIBILITY

SUSCEPTIBILITY TEST DATA

ITEM TESTED: QUAD REDUNDANT VALVE SER.NO. 128 TEST NO. E-1256

TYPE OF TEST: RADIATED (LOOP) SPEC. NO MIL-I-6181D PARA: 4.3 4.3

CONDUCTED BY: JCJ DATE: 5-30-67 CHECKED BY: [illegible]

ITEM TESTED LINE VOLTAGE: AC: ——— DC: 22 VDC

FREQ.	LOOP POSITIONED NEAR ELECTRICAL POWER ENTRY POINT
150 KC	NO INDICATION OF SUSCEPTIBILITY
↓	↓
1 GC	

NOTE: 1.) All frequencies not listed are scanned for malfunction or degradation of performance.

Thiokol
REACTION MOTORS DIVISION

APPENDIX N

PROPELLANT COMPATIBILITY TEST

QUADREDUNDANT VALVE
(P/N 317013-500, S/N 128)

TEST OBJECTIVES

To demonstrate compatibility of the quadredundant valve with the propellants used on the C-1 RES as part of the valve qualification testing.

ITEM TESTED

Quadredundant Valve RMD P/N 317013-500, S/N 128
Manufacturer: Moog, Ind., East Aurora, New York

SPECIFICATION

RMD Specification 1425

DATE OF TEST: 22 May 67 to 29 May 67

SUMMARY

The quadredundant valve completed the test and met all the requirements of the Specification. There were indications of a slight reaction between the sealant (PR 1538) used in potting the diode in the torque motor cover and the propellants.

TEST PROCEDURE

The compatibility test was conducted in accordance with RMD Specification 1425.

The valve was visually checked and the electrical characteristics measured (prior to and at the completion of each phase of the test in accordance with the success/failure criteria of the specification.

TEST RESULTS

At the completion of the external compatibility test made with fuel only slight staining and/or discoloration was noted. This occurred mainly on torque motor covers and around the potting where the leads enter the cover. There was no evidence of electrical insulation or resistance degradation after exposure to the fuel propellant. (See Figure 1 for summary of results, Appendix for original data).

Thiokol CHEMICAL CORPORATION
REACTION MOTORS DIVISION
DENVILLE NEW JERSEY

COMPONENT DEVELOPMENT LABORATORY DATA SHEET

TITLE Compatibility Tests		
PROJECT NO. 6222-66-5002	P. O. NO.	PART NAME Gate Valve
CONTRACT NO.	USED ON	PART NO. 317013-5 CHG LTR G
PREPARED BY D. Gregory	APPLIC. SPEC. 1277	SER. NO. 128
APPROVED BY	DATE OF TEST 5/22/67	MFR
R. M. D. INSPECTOR	TEST SKETCH YES NO	TEST NO. REPORT NO.
GOV'T INSPECTOR	GRAPH YES NO	PAGE OF PAGES

INSTR. DATA BLOCK

INSTR.	SER. NO.	CAL. DT.		INSTR.	SER. NO.	CAL. DT.		INSTR.	SER. NO.	CAL. DT.
Bridge	70230 N	7-11-67								
P.S.	CC168	7-1-67								

4.2.3.1 ELECTRICAL RESISTANCE

PINS	VALVE	TEMP	Ohms
A-C	1	78F	22.4
F-D	2		22.4
H-K	3		22.5
N-L	4		22.4
R-T	5		22.5
W-U	6		22.5
G-Y	7		22.5
P-Z	8		22.5

4.2.3.2 INSULATION RESISTANCE

ALL PINS TO GND PER Spec. 4.2.3.2 TEST PROCEDURE
POTENTIAL - 500 VDC
DURATION - ONE MINUTE
INSULATION RESISTANCE = ∞

RMD RE 167

Thiokol CHEMICAL CORPORATION
REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

COMPONENT DEVELOPMENT LABORATORY DATA SHEET

TITLE ELECTRICAL TEST		
PROJECT NO. 6222-66-5002	P. O. NO.	PART NAME QUAD. VALVE
CONTRACT NO.	USED ON	PART NO. 317013-500 REV LTR G
PREPARED BY Campbell	APPLIC. SPEC. 1277	SER. NO. 128
APPROVED BY	DATE OF TEST 5-24-67	MFR
R. M. D. INSPECTOR Haggerty	TEST SKETCH YES NO ✓	TEST NO. REPORT NO.
GOV'T INSPECTOR	GRAPH YES NO ✓	PAGE OF PAGES

INSTR. DATA BLOCK

INSTR.	SER. NO.	CAL. DT.		INSTR.	SER. NO.	CAL. DT.		INSTR.	SER. NO.	CAL. DT.
Cimron	4427	4-3-67	0.05%	RESISTANCE						
WAMETR	42	3-16-67	1%	—						

	Coil Ω
L-1	22.50
L-2	22.53
L-3	22.43
L-4	22.45
L-5	22.41
L-6	22.43
L-7	22.43
L-8	22.41

COIL RESISTANCE MEASUREMENTS

INSULATION RESISTANCE

L-1 TO L-8 SHORTED TOGETHER

FROM CASE TO COILS = ∞
@ 500 VDC ± 50 V

RMI 68

RMD RE 167

(2)

Thiokol, CHEMICAL CORPORATION
REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

COMPONENT DEVELOPMENT LABORATORY DATA SHEET

TITLE ELECTRICAL TEST - EXTRA TEST ENGINEERING		
TEST COMPLETED BETWEEN OXIDIZER SPRAY & VAPOR TESTING.		
PROJECT NO. 6422-66-5002	P. O. NO.	PART NAME QUAD VALVE
CONTRACT NO.	USED ON	PART NO 317013-50 CHG LTR G
PREPARED BY [illegible]	APPLIC. SPEC. 1277	SER. NO. 128
APPROVED BY	DATE OF TEST 5-26-67	MFR —
R. M. D. INSPECTOR [illegible]	TEST SKETCH YES NO ✓	TEST NO. — REPORT NO.
GOV'T INSPECTOR [illegible]	GRAPH YES NO ✓	PAGE — OF — PAGES

INSTR. DATA BLOCK

INSTR.	SER. NO.	CAL. DT.		INSTR.	SER. NO.	CAL. DT.		INSTR.	SER. NO.	CAL. DT.
[illegible]	1427	4-3-67	0.05%	RESISTANCE						
[illegible]	42	3-1-67	1%		—					

COIL RESISTANCE MEASUREMENT —Ω

L-1	22.23
L-2	22.11
L-3	22.11
L-4	22.11
L-5	22.09
L-6	22.09
L-7	22.09
L-8	22.09

INSULATION RESISTANCE

L-1 TO L-7 SHUNTED TOGETHER

FROM CASE TO COILS = ∞
@ 500 VDC ± 50 V

L-8 250 MΩ

(3)

Thiokol CHEMICAL CORPORATION
REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

COMPONENT DEVELOPMENT LABORATORY DATA SHEET

TITLE Compatibility Tests		
PROJECT NO 6222-66-5002	P. O. NO.	PART NAME Quad Valve
CONTRACT NO.	USED ON	PART NO. 317013 CHC LTR 500 G
PREPARED BY V.B. Anko	APPLIC. SPEC. 1277	SER. NO. 128
APPROVED BY	DATE OF TEST 5/27/67	MFR —
R. M. D. INSPECTOR	TEST SKETCH YES NO ✓	TEST NO. — REPORT NO. —
GOV'T INSPECTOR	GRAPH YES NO ✓	PAGE — OF — PAGES

INSTR. DATA BLOCK

INSTR.	SER. NO.	CAL. DT.		INSTR.	SER. NO.	CAL. DT.		INSTR.	SER. NO.	CAL. DT.
CIMRON		4427	(4-3-67)		.05%		RESISTANCE			
INSUL. TESTER		LAMEDA	28-29		1%		(5-1-67)			

Coil Resistance Measurement (Ω)

L1	22.60
L2	22.63
L3	22.57
L4	22.49
L5	22.53
L6	22.50
L7	22.57
L8	22.53

5/29/67
INSULATION RESISTANCE @ (500 VDC) = ∞ megohms

RMD RE 167

(4)

Thiokol. CHEMICAL CORPORATION
REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

COMPONENT DEVELOPMENT LABORATORY DATA SHEET

TITLE QUAD VALVE - FLUSHING		
PROJECT NO. 6222-66-5002	P. O. NO.	PART NAME VALVE -
CONTRACT NO.	USED ON C-1	PART NO. 3170B-510 CHG LTR G
PREPARED BY J. Rogers	APPLIC. SPEC.	SER. NO. 128
APPROVED BY	DATE OF TEST 5-29-67	MFR MOOG
R. M. D. INSPECTOR	TEST SKETCH YES NO ✓	TEST NO. 1 REPORT NO. 1
GOV'T INSPECTOR	GRAPH YES NO ✓	PAGE 1 OF 1 PAGES

INSTR. DATA BLOCK

INSTR.	SER. NO.	CAL. DT.		INSTR.	SER. NO.	CAL. DT.		INSTR.	SER. NO.	CAL. DT.
GAGE	1000-1	5-15								

1. ATTACHED SOURCE OF FILTERED FREON FLUSHING FLUID TO OX & FUEL INLETS OF SUBJECT VALVE, ACTUATED ALL SOLENOIDS TO OPEN POSITION, REDUCED VOLTAGE METER OPENING TO 6 V. D. C. — FLUSHED EACH PROPELLANT CIRCUIT WITH FREON UNTIL A MINIMUM OF 8 OZS OF FLUID WAS COLLECTED FROM OUTLET OF VALVE ASSY.

2. REDUCED FLUID PRESSURE TO ZERO, ATTACHED FILTERED SOURCE OF NITROGEN TO INLETS. PURGED EACH PROPELLANT CIRCUIT WITH 30-40 # PSIG N_2 FOR 5 MINUTES MINIMUM.

3. REDUCED NITROGEN PRESSURE TO ZERO, REMOVED ELECTRICAL SIGNAL & DISCONNECTED VALVE FROM SYSTEM.

(9)

At the completion of the external compatibility test made with oxidizer there was evidence of a reaction between the sealant (PR 1538) used in potting the diode in the torque motor cover. There was no evidence of corrosion or incompatibility of the base material or any other material used in the construction of the valve. There was no evidence of electrical insulation or resistance degradation after exposure to oxidizer propellant. During the electrical insulation test some degradation was noted, but after local drying of the connector and cable (drive out the moisture trapped after flushing with H_2O per specification) the apparent discrepancy disappeared. Figure 1 summarizes the data obtained during the test. (See Appendix for original data).

QUADREDUNDANT VALVE

Coil Resistance 23 ±1.7 ohms

Test Pins	Torq. Motor	Temp	Prior to Fuel Compatibility	After Fuel Compatibility	After Oxidizer Compatibility (Spray)	After Oxidizer Compatibility (Vapor)
A-C	1	78°F	22.4	22.5	22.23	22.6
F-D	2	78°F	22.4	22.53	22.11	22.63
H-K	3	78°F	22.5	22.43	22.11	22.57
N-L	4	78°F	22.6	22.45	22.07	22.49
R-T	5	78°F	22.5	22.41	22.09	22.53
W-U	6	78°F	22.5	22.43	22.09	22.50
G-Y	7	78°F	22.5	22.43	22.09	22.57
P-Z	8	78°F	22.5	22.41	22.09	22.53

Insulation Resistance > 100 megohms

Thiokol
REACTION MOTORS DIVISION

APPENDIX O

VALVE QUALIFICATION ACCELERATION TESTING OF ONE QUADREDUNDANT VALVE P/N 317013-500, S/N 123

CDL REPORT 1691

CDL REPORT NO. 1691
14 June 1967

VALVE QUALIFICATION ACCELERATION TESTING OF ONE (1) QUADREDUNDANT VALVE, P/N 317013-500 S/N 123

PROJECT NUMBER
6222-66-5003

DATE OF TESTING
10 June 1967 thru 14 June 1967

Prepared by Victor F. Banko
Victor F. Banko

Approved by _____
C. W. Busch

Approved by _____

OBJECTIVE

The purpose of this test is to demonstrate the ability of the quadredundant valve to perform to specification during and after exposure to acceleration levels specified herein.

SUMMARY

The quadredundant valve met all the requirements of the acceleration test as delineated in RMD Spec 1433. No adverse effects or test malfunctions were noted.

TEST DESCRIPTION

The valve-RES assembly was mounted in a fixture simulating its normal mounting configuration and mounted in the centrifuge. Acceleration was applied in each direction of the three (3) mutually perpendicular axis as specified in Figures 1 and 2 of Spec 1433. The valve was accelerated, pressurized and non-operating at 20 g's for six minutes and pressurized and operating at 20 g's for two minutes. Response and leakage tests were performed during and after the accelerations in accordance with Spec 1433.

TEST EQUIPMENT

1. Centrifuge - Schaevitz Type P100A
2. Test Racks - X316293, CDL-296, CDL-295
3. Test Fixtures - SA 12638
4. Oscilloscope - Tektronix Type 535 Type M Plugin
5. Scope Camera - Tektronix C-12
6. Pressure Gage - Helicoid 8 1/2", 0 to 600 psi
7. D.C. Power Supplies - Kepco KS-36-15M; Opad KM-81

CONCLUSIONS

The quadredundant valve met the acceleration test requirements. No conclusions are drawn or recommendations necessary. The data is merely submitted.

Before Accel.

Spec. 1277

Page 22

Test No. _____

Acceptance Test Data Sheet

Purchase Order No. _____ Serial No. 123

Part Name Mooo Quad Valve Date of Test 6-10-67

RMD Part No. 317012-500 Chg. Letter _____

4.2.9.2 Reverse Seat Leakage

	Fuel L-3, L-4 Open	Ox L-7, L-8 Open	
Outlet Port Pressure	20	20	psig (20±1)
Leakage at			
Fuel Inlet	NONE	—	scc/hr (30 max)
Ox Inlet	—	NONE	scc/hr (30 max)
	L-1, L-2 Open	L-5, L-6 Open	
Outlet Port Pressure	20	20	psig (20±1)
Leakage at			
Fuel Inlet	NONE	—	scc/hr (30 max)
Ox Inlet	—	NONE	scc/hr (30 max)

4.2.9.3 Internal Leakage

	Fuel Valves L-3, L-4 Open	Ox Valves L-7, L-8 Open	
Inlet Port Pressure	50	50	psig (50±5)
Fuel Seat Leakage	NONE	—	cc/hr (5 max)
Oxidizer Seat Leakage	—	NONE	cc/hr (5 max)
Inlet Port Pressure	325	325	psig (310±10)
Fuel Seat Leakage	NONE	—	cc/hr (5 max)
Oxidizer Seat Leakage	—	NONE	cc/hr (5 max)
	L-1, L-2 Open	L-5, L-6 Open	
Inlet Port Pressure	50	50	psig (50±5)
Fuel Seat Leakage	NONE	—	cc/hr (5 max)
Oxidizer Seat Leakage	—	NONE	cc/hr (5 max)
Inlet Port Pressure	325	325	psig (310±10)
Fuel Seat Leakage	NONE	—	cc/hr (5 max)
Oxidizer Seat Leakage	—	NONE	cc/hr (5 max)

Cycles 2

Operator [illegible]

Inspector [illegible]

Before Accel

Spec 1277

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Test No. _____

Acceptance Test Data Sheet

Purchase Order No. _____ Serial No. 123

Part Name Nozz Quad Valve Date of Test 6-10-67
RMD Part No. [illegible] Chg. Ltr. _____

4.2.9.4 External Leakage (all valves opened)

External -

Inlet Pressure 325 psig (~~310-310~~)
External Leakage None cc/sec (10^{-4} max)

_____ cc/sec (1 cc/h max.)
K seal location only.

Cycles _____
Operator _____
Inspector _____

5.2 Packaging - _____

Total Cycles _____

CP

RE

CALCULATION OR REPORT NO. | PAGE | OF

SECURITY INFORMATION

PREP. BY

CHKD. BY

TITLE: ACCELERATION TEST

SEQUENCE	AXIS	PRESS.	g	DURATION	OPERATING CYCLE	INSPECTION
①	A −	166 psig	20	6 min.	NONE	RMI 62 M NASA 561
②						PORT. W VISUAL RMI 62 M NASA 561
③	A +	166 psig	20	6 min.	NONE	RMI 62 M NASA 561
④						PORT W VISUAL RMI 62 M NASA 561
⑤					(1) RESPONSE	See Below RMI 62 M NASA 561
⑥	A +	166 psig	20	120 sec	10 cps ACT. (2) RESPONSE	See Below RMI 62
⑦	A −	166 psig	20	120 sec	10 cps ACT. (2) RESPONSE	See Below RMI 62
⑧						INTERNAL RMI 62 M NASA 561

PRE-TEST	L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8	
OPENING	11.5	11.0	11.5	11.5	5.0	5.0	5.0	11.0	M.S. RMI 62 M NASA 561
CLOSING	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	M.S.
OPENING A − N	6.0	6.0	4.5	5.0	4.0	4.5	4.0	6.0	M.S. RMI 62 M NASA 561
CLOSING	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	M.S.
OPENING	5.0	6.0	6.0	5.0	4.0	4.0	6.0	6.0	M.S. RMI 62
CLOSING A +	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	M.S.
OPEN	4.0	4.0	4.0	4.0	4.0	6.0	6.0	4.0	RMI 62
CLOSE	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	
OPEN	4.0	4.0	4.0	4.0	4.0	6.0	6.0	5.0	
CLOSE	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	

SECURITY INFORMATION

Thiokol CHEMICAL CORPORATION
REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

OGILVIE PRESS INC., BROOKLYN 17, N. Y.
REPRODUCED NO. 440H

RMD 33 256

after "A" Axis Acceleration

Spec. 1277

Page 15

Test No. _____

Acceptance Test Data Sheet

Purchase Order Number _____ Serial No. 153

Part Name Quad valve Date of Test 6-11-67

RMD Part No. 317013-500 Chg. Letter —

4.2.9.3 Internal Leakage

	Fuel Valves L-3, L-4 Open	Ox Valves L-7, L-8 Open	
Inlet Port Pressure	50	50	psig (50±5)
Fuel Seat Leakage	NONE	—	cc/hr (5 max)
Oxidizer Seat Leakage	—	NONE	cc/hr (5 max)
Inlet Port Pressure	325	325	psig (~~310~~ 310±10)
Fuel Seat Leakage	NONE	—	cc/hr (5 max)
Oxidizer Seat Leakage	—	NONE	cc/hr (5 max)
	L-1, L-2 Open	**L-5, L-6 Open**	
Inlet Port Pressure	50	50	psig (50±5)
Fuel Seat Leakage	NONE	—	cc/hr (5 max)
Oxidizer Seat Leakage	—	NONE	cc/hr (5 max)
Inlet Port Pressure	325	325	psig (310±10)
Fuel Seat Leakage	NONE	—	cc/hr (5 max)
Oxidizer Seat Leakage	—	NONE	cc/hr (5 max)

Cycles _____

Operator _____

Inspector _____ 6-11-67

4.2.9.2 Reverse Seat Leakage

	Fuel L-3, L-4 Open	Ox L-7, L-8 Open	
Outlet Port Pressure	20	20	psig (20±1)
Leakage at			
Fuel Inlet	NONE	—	scc/hr (~~30~~ max)
Ox Inlet	—	NONE	scc/hr (~~30~~ max)
	L-1, L-2 Open	**L-5, L-6 Open**	
Outlet Port Pressure	20	20	psig (20±1)
Fuel Inlet	NONE	—	scc/hr (~~30~~ max)
Ox Inlet	—	NONE	scc/hr (~~30~~ max)

6-11-67

"B" Axis - [illegible] (Dual Test) [illegible]

RE

CALCULATION OR REPORT NO. | PAGE | OF

SECURITY INFORMATION

PREP. BY | CHKD. BY

TITLE: ACCELERATION TEST

SEQUENCE	AXIS	PRESS.	g	DURATION	OPERATING CYCLE	INSPECTION
①	B −	166 psig	20	6 min.	NONE	RMI 62 / M NASA 56T
②						PORT. W VISUAL RMI 62 / M NASA 56T
③	B +	166 psig	20	6 min.	NONE	RMI 62 / M NASA 56T
④						PORT W VISUAL RMI 62 / M NASA 56T
⑤					(1) RESPONSE	See Below
⑥	B +	166 psig	20	120 sec	10 cps ACT. (2) RESPONSE	See Below RMI 62
⑦	B −	166 psig	20	120 sec	10 cps ACT. (2) RESPONSE	See Below RMI 62
⑧						INTERNAL RMI 62 / M NASA 56T

OPR.	L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8	
Pre. TEST	7.0	7.0	5.0	5.0	5.0	5.0	8.0	7.0	RMI 62 / M NASA 56T
B+ Close	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	
Open	4.0	4.0	8.0	8.0	4.5	4.5	7.0	7.0	
close	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	RMI 62 / M NASA 56T
Open	4.0	4.0	8.0	8.0	4.5	4.5	7.0	7.0	
Close	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	RMI PP / M NASA 56T
B− Open	8.5	8.5	5.0	5.5	8.0	8.0	6.0	5.0	
close	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	RMI 4P / M NASA 56T
Open	8.5	8.5	5.0	5.0	9.5	9.5	5.5	5.5	
Close	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	RMI 4P / M NASA 56T
Open									
Close									
Open									
Close									

SECURITY INFORMATION

Thiokol CHEMICAL CORPORATION
REACTION MOTORS DIVISION
DENVILLE, NEW JERSEY

RMD RE 256

OGILVIE PRESS INC., BROOKLYN 17, N. Y.
REPROVEL NO. 440H

AFTER "B" AXIS ACCELERATION

Spec. 1277

Page 22

Test No. _____

Acceptance Test Data Sheet

Purchase Order No. _____ Serial No. 123

Part Name Quad Valve Date of Test 6-12-67

RMD Part No. 312313-500 Chg. Letter —

4.2.9.2 Reverse Seat Leakage

	Fuel L-3, L-4 Open	Ox L-7, L-8 Open	
Outlet Port Pressure	20	20	psig (20±1)
Leakage at			
Fuel Inlet	NONE	—	scc/hr (~~30~~ 200 max)
Ox Inlet	—	NONE	scc/hr (~~30~~ max)
	L-1, L-2 Open	L-5, L-6 Open	
Outlet Port Pressure	20	20	psig (20±1)
Leakage at			
Fuel Inlet	NONE	—	scc/hr (~~30~~ 200 max)
Ox Inlet	—	NONE	scc/hr (~~30~~ max)

4.2.9.3 Internal Leakage

1 CYCLE DRY

	Fuel Valves L-3, L-4 Open	Ox Valves L-7, L-8 Open	
Inlet Port Pressure	50	50	psig (50±5)
Fuel Seat Leakage	NONE	—	cc/hr (~~5~~ max)
Oxidizer Seat Leakage	—	NONE	cc/hr (~~5~~ 200 max)
Inlet Port Pressure	325	325	psig (~~310~~ 325±10)
Fuel Seat Leakage	NONE	—	cc/hr (~~5~~ max)
Oxidizer Seat Leakage	—	NONE	cc/hr (~~5~~ 200 max)
	L-1, L-2 Open	L-5, L-6 Open	
Inlet Port Pressure	50	50	psig (50±5)
Fuel Seat Leakage	NONE	—	cc/hr (~~5~~ max)
Oxidizer Seat Leakage	—	NONE	cc/hr (~~5~~ 200 max)
Inlet Port Pressure	325	325	psig (~~310~~ 325±10)
Fuel Seat Leakage	NONE	—	cc/hr (~~5~~ max)
Oxidizer Seat Leakage	—	NONE	cc/hr (~~5~~ 200 max)

Cycles ONE DAY

Operator P. Cain

Inspector _____

RMI 62

Acceptance Test Data Sheet

Purchase Order No. _____ Serial No. 123

Part Name Guard Valve Date of Test 6-12-67
RMD Part No. 311013-500 Chg. Ltr. _____

4.2.8 Cleanliness Verification

100 ml sample taken downstream of valve.

Micron Size	Limitations	Actual
10-25	2150	
25-50	530	
50-100	60	
100-300	10	
300+	0	
Fibers	10	

N.A.

4.2.9.1 Drying

Vacuum 4 mmHG (4 mm max)
Time 4 hrs (4 hrs min)
Cycles one
Operator [illegible]
Inspector [illegible]

4.2.3.1 Electrical Resistance

Resistance A to C _____ ohms
Resistance F to D _____ ohms
Resistance H to K _____ ohms
Resistance N to L _____ ohms
Resistance R to T N.A. ohms
Resistance W to U _____ ohms
Resistance G to Y _____ ohms
Resistance P to Z _____ ohms

Cycles _____
Operator _____
Inspector _____

CP

RE

CALCULATION OR REPORT NO. | PAGE | OF

SECURITY INFORMATION

PREP. BY | CHKD. BY

TITLE: ACCELERATION TEST

SEQUENCE	AXIS	PRESS.	g	DURATION	OPERATING CYCLE	INSPECTION
①	C-	166 psig	20	6 min.	NONE	RMI 62
②						PORT W VISUAL
③	C+	166 psig	20	6 min.	NONE	RMI 62
④						PORT W VISUAL
⑤					(1) RESPONSE	RMI 62
⑥	C+	166 psig	20	120 sec	10 cps ACT. (2) RESPONSE	RMI 62
⑦	C-	166 psig	20	120 sec	10 cps ACT. (2) RESPONSE	RMI 62
⑧					C.E.C.	INTERNAL RMI 62

	L-1	L-2	L-3	L-4	L-5	L-6	L-7	L-8
Pre. Test Open	6.0	6.0	5.0	5.0	5.0	4.5	7.0	9.0
Close	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
C+ Open	5.0	5.0	6.0	6.0	5.0	5.5	6.0	6.0
Close	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Open	5.0	5.0	6.0	6.0	5.0	5.0	6.5	6.0
Close	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
C- Open	6.0	6.0	7.0	7.0	11.5	11.5	6.5	5.0
Close	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Open	4.5	4.5	9.0	9.0	12.5	12.5	5.5	5.0
Close	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Open								
Close								

SECURITY INFORMATION

Thiokol CHEMICAL CORPORATION
REACTION MOTORS DIVISION
Denville, New Jersey

RMD 88 256

OGILVIE PRESS INC., BROOKLYN 17, N. Y. REPRODUCEL NO. 440H

THIOKOL CHEMICAL CORPORATION
Reaction Motors Division

Page 1 of 1
C-1

Res 760 with Quad 123

LEAK TEST DATA (RMD Spec 7717)

Part No. X317000 Chg _____ Serial No. 760

Test No.	Press. Port	(Psig) Test Press.	Allow. Atm Leak. cc/hr	Points	Result	Insp
1a	R	325±5	230.0	1. Port W (Past Seat)	N.A.	
			9.0	2. Valve Inlet Fitting	N.A.	
1b	R	"	230.0	1. Port W (Past Seat)	NONE	RMI 62
			9.0	2. Valve Inlet Fittings (Ports R & K)	NONE	
2a	N	"	230.0	1. Port W	N.A.	
			9.0	2. Valve Inlet (Port N)	N.A.	
				3. Fuel Outlet (Port T)	N.A.	
				4. All Welds	N.A.	
2b	N	"	230.0	1. Port W	NONE	RMI 62
			9.0	2. Valve Inlet (Port N)	NONE	
				3. Fuel Outlet (Port T)	NONE	
				4. Fuel Vent (Port H)	NONE	
				5. All welds	NONE	
3a	R & N	"	9.0	1. Fuel Valve Outlet Seal (Port S)	N.A.	
				2. Ox Valve Outlet Seal (Port R)	N.A.	
				3. Pch. Seal (Port P)	N.A.	
				4. Valve	N.A.	
3b	R & N	"	9.0	1. Fuel Valve Outlet Seal (Port S)	NONE	RMI 62
				2. Ox Valve Outlet Seal (Port R)	NONE	
				3. Pch Seal (Port P)	NONE	
				4. Valve	NONE	
4a	P	20±1	26.8	1. Ox Inlet (Port R)	N.A.	
				2. Fuel Inlet (Port N)	N.A.	
4b	P	"	26.8	1. Ox Inlet (Port R)	NONE	RMI 62
				2. Fuel Inlet (Port N)	NONE	
5a	P	10.5±.5	4.5	1. Nozzle Extension Seal (Port X) 5.6	NONE	
		4.0±1.0	4.5	2. Thrust Chamber to Valve (Port C)	N.A.	
5b	P	4.0±1.0	4.5	1. Thrust Chamber to Valve (Port C)	NONE	RMI 62

Date Completed 6-13-67 Time 10:30 Am. Cycles 2

NOTE: Fill out Leakage Report (Page 18 of Spec), in duplicate
QC 056066 1 Copy Q. C. History - 1 Copy Reliability

THIOKOL CHEMICAL CORP.

REACTION MOTOR DIVISION

4 HRS DRY NIT LEAK TEST
AFTER ACCELERATION 6/13/67
QUAD VALVE 123
WITH RGS
RCS-760

SPEC. NO. 7717
CLASS II PARA 8.2

CALIBRATION

CAL. NO.	OPERATOR	LOCATION OF APPARATUS	DATE	ROOM TEMP. FAHRENHEIT	STD. LEAK	(DIV. x MULT.)	BASIC SENSITIVITY ATM cc/sec/div	DIATRON PRESS.
1	R.J.G.	ENG LAB	6-13-67	77°	10^{-6}	26X100	2.6×10^{-7}	N/A
2								
3								
4								
5								
6								
7								
8								
9								
10								

CAL. NO.	LN_2 TRAP FILLED	IONIZING CURRENT	ACCEL. VOLTAGE	PROBE STD. LEAK	DIV. x MULT.	PROBE SENSITIVITY ATM cc/sec/DIV.	DIATRON PRESS.
1	✓	M.S.	73 V	520 cc/sec	5X500	1042	.21 N/C
2							
3							
4							
5							
6							
7							
8							
9							
10							

FIGURE 2